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THE RECENT PROGRESS OF SOLAR PHYSICS.*

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LEAVING to those of wider knowledge the survey of the whole field of scientific labor, it has seemed to me that I could best present to you some account of that branch of it with which I am most familiar, which is that of "Solar Physics."

This study is essentially a modern one. Astronomy, which in the earliest times could only mark the annual path of the sun, or count the stars, with the invention of the telescope still concerned itself more with the motions of the heavenly bodies than with their physical nature. It sought out new methods of precision to fix the places of these stars and to mark out for the navigator the path of the moon on the celestial dial; it united itself intimately with the sister science of mathematics in predicting the places of the heavenly bodies from the law of gravitation, but it was still as a surveyor and marker of boundaries in the field of space that the observer chiefly labored, and we associate the most striking triumphs of the classic astronomy with this work of precision. It is this aspect that appeals even to the imagination, and which is seized as distinctive by the poet of Urania:

> "That little Vernier on whose slender lines
> The midnight taper trembles as it shines,
> Tells through the mist where dazzled Mercury burns,
> And marks the spot where Uranus returns."

These are noble aims, and noble results; but it is curious to see how observers of the last century, who had learned this excellent lesson

* Address before the Physical Section of the American Scientific Association at Saratoga.

of precision, had learned no other, and remained indifferent to a great question to which the old methods did not apply. We are called into existence by a great central fire, the sun, by which we continue to exist from one hour to another. What is it? what is this heat which it pours into space, and with whose cessation we shall cease? How long will it continue to feed our lives? A few years ago, with almost the sole exceptions of the Herschels and Pouillet, no one even asked these questions, much less intelligently sought their solution.

It is hard to say to whom the awakening of attention is due; yet if any one were to be named, it should perhaps be the Italian physicist Melloni, "the Newton of heat."

His book, "La Thermochrose," has to me an attraction of its own, for the author, with the ingenuous confidence of his nation, begins, not by describing his thermopile or galvanometer, but by taking the reader into his personal experience, and telling him how even as a child he felt an invincible curiosity about what we have just seen hardly any one else then cared for, and how, rising long before dawn, he loved to seek some quiet spot, to wait there in the silence of the sleeping world the first beams of the sun, and as he felt their warmth and heard the stir of life they awakened round him, how he too was stirred with wonder and interest as to the nature of that mysterious thing, radiant heat, and resolved to give his future to its study. If to distinguish a cause for wonder and inquiry in what to the common mind has called for neither be a characteristic of genius, then Melloni must be allowed its possession, and in his but too short years he showed the world how much interest and importance lay in this then neglected study, which so many with clearer knowledge and better methods follow to-day.

Fraunhofer's previous work had prepared the way for the spectroscope, and with the now awakened interest in these questions, its employment by Kirchhoff in 1860 may be said to inaugurate the present study of solar physics, as distinguished from the classic astronomy, which concerned itself with number and measure first, and in a wholly secondary degree with the physical characteristics of the heavenly bodies. This study occupies itself with the former, indeed, but chiefly in aid of other investigations, and by the study of solar physics then, we mean much more than a telescopic examination of the sun; we mean besides this the analysis of its radiations by the spectroscope, their summation by the photometer and thermopile, the determinations of its heat and the possible effects of changes in it on terrestrial meteorology, and generally the pursuit of all those problems which unite the methods of physics and astronomy.

In 1860 we already knew that the sun was surrounded by an envelope then visible only during total eclipses, and which was surmised to be gaseous; and of the sun itself we knew very little more than that it was a hot globe with spots upon it; for, though Schwabe had

observed the periodicity of the spots, and Carrington was already at work, their results were not wholly public, and the facts of the variable velocity of the sun's rotation were rather the surmises of a few than part of the body of acquired knowledge. Since then this branch of astronomy has grown almost to the position of an independent science, and, though it has not yet been distinctly divided into specialties in its turn like its elder sisters, yet we already see a tendency to their formations. Thus, with the study of the motions of the solar surface we associate with the names just mentioned those of Sporer, De la Rue, and Wolf; with eye-studies of the photosphere or solar meteorology, those of Dawes, Secchi, and others; with the telescopic use of the spectroscope those of Huggins, Janssen, Lockyer, Secchi, Young, and Tacchini. The work of mapping the spectrum, begun by Kirchhoff, has been continued by Angstrom, Mascart, and Cornu, while photography, in the hands of Rutherfurd, Janssen, and Draper, has largely superseded telescopic studies of the photosphere, and the list might be enlarged indefinitely. Let us glance at part of the work done by these during the past twenty years, for their labors make the history of our study.

The work of Carrington, completed in 1861, taught us what had before been suspected—both the periodicity of the spots and that this great globe, so far as we can see it, has different periods of rotation, its equatorial zones completing a revolution in less time than its polar ones. We know very little more on this point now, the cause of both phenomena remaining wholly mysterious to-day.

In the next year (1862) an impulse was given to the study of the solar surface by the announcement of a supposed discovery of gigantic individual bodies in it, of from 500 to 1,000 miles in length, distinct from each other, and existing in countless numbers. This extraordinary statement was not easily disproved, as it is with great difficulty that the real structure is discernible by the best telescopes. Forms, we can scarcely call them "bodies," are undoubtedly there, of a size and in numbers which could only exist on so vast a surface, and which are no doubt the chief immediate cause of the sun's light and heat —but what are their causes in turn, and what is their real nature? The suggestion was made at the time by the then, perhaps, most eminent living astronomer, that they might be, in a sort, living things—*beings*, in fact, whose vital force gave us the solar heat; a suggestion which we may smile at now, but which was received at the time with a kind of awe, as adumbrating some possible truth. Of its author I would speak with all possible respect in citing it, which I do here, as nothing can better indicate the obscurity of our knowledge, even at so recent a period. We may look back on such a possible suggestion and its connection with that "vital force," now itself banished by physiology, as a kind of landmark on the road we have traveled. Our science, young as it is, is old enough to have had its age of fable.

Since that time, in France, in Italy, in England, and here, thousands of telescopic studies have been made with the purpose of defining these forms, and of learning more about the growth of those mysterious objects with which they are associated—the sun's spots, which drew the attention of Fabricius and Galileo, and which still attract our own more than ever to-day, with problems which seem nearly insoluble. Everything we see convinces us that the solar surface in which they are formed is neither a solid nor a liquid, but composed of volumes of whirling vapors; yet through this vapor, which seems to offer no resistance, come eruptions of explosive violence such as one would suppose must arise from the sudden bursting of some rigid shell. The turmoil within the areas of disturbance is so great, the area itself so vast and inclosing such diversities of action, that we are still doubtful how far this action is downward, how far upward.

Under the circumstances, we can hardly say that twenty years of observation in this department have brought us results commensurate with the labor expended, nor have we derived great aid from photography until some recent advances of which I have presently to speak.

A review of our past studies of the corona is a review of the solar eclipses during the past twenty years; for it is a fact, unparalleled in the sciences of observation, that the opportunities for this knowledge last only minutes, and are separated by intervals of years. Till 1860 it was uncertain whether the protuberances belonged to the sun or moon, but in that year the then newly applied photographic method made it nearly certain that they were parts of the former, and previous surmises that they were extensions of an envelope everywhere surrounding the sun were confirmed. In 1868 some traces of the corona were first photographed. The spectroscope was used upon the prominences, their gaseous nature was proved, and nine of the chromospheric lines were determined; and nearly together Messrs. Janssen and Lockyer made the discovery that these lines could be seen without an eclipse; 1869 brought that eclipse which traversed our own territory, and in this the distinctive coronal line was first observed by Young and by Harkness; while in this, and yet more in the eclipse of 1870 and 1871, we obtained better photographs of the corona, and greatly increased our knowledge of its apparent structure.

It is hardly possible to present even in the briefest way any review here of the separate history of spectroscopic research since 1860, during which time it has been connected with most of the important steps in every field of our study. It has, in the hands of Messrs. Huggins, Zöllner, and Young, made visible to us the forms of the chromosphere, and enabled us to measure the velocity of motions upon the sun otherwise beyond estimate, while at the same time it has given us independent data for the absolute velocity of other suns in space, and for that of the rotation of our own solar photosphere. It has, in the hands of Secchi and others, connected our knowledge of our sun's

physical constitution, and perhaps of its past history with that of other suns, and even assumed to give us information whence we might infer something as to their mass, as well as physical constitution, while it has immensely increased the number of lines mapped twenty years since in the spectrum, and modified the ideas we then entertained as to the interpretation of these lines themselves.

The important question of the amount of heat received from the sun has been the subject of almost uninterrupted experiment and study during the period under review, but without essentially altering the data of Herschel and Pouillet which we already possessed. In this field the French physicists and our countryman, Mr. Ericsson, have been prominent workers, and we have attained results possessing all desirable certitude relatively to our knowledge in other branches.

Investigations on the solar temperature have been carried on by many observers, but with results which are thus far less satisfactory.

I am painfully sensible of the inadequacy of this review of the history of solar physics, but the brief time before me warns me to come from its past to its present. Within the last two years the difficulties I have alluded to, as so great in eye-studies of the solar surface, have been singularly modified by the remarkable advance of solar photography at the hands of M. Janssen. When I recently visited his observatory at Meudon, I found him producing original negatives on a scale of nearly thirty English inches to the solar diameter, and which bear enlargement to nearly ten feet with remarkable precision; and one of these negatives, which presents over a million discrete cloud-forms, can be taken in $\frac{1}{1000}$ of a second. In another branch of photography, that of the reproduction of spectral lines, for which so much is due to Rutherfurd and Draper, I know nothing more surprising than the recent success of Captain Abney (of the Royal Engineers) at South Kensington, who has photographed the red end of the spectrum, and far beyond the red end, to a wave-length of about 12,000. As this statement may of itself convey no clear idea to some of my audience, let me explain in less technical language that it means we can now photograph objects in absolute darkness—objects which are not luminous—simply by the heat they give out. This is a discovery which obviously lends itself to important practical applications, while it is of further interest as bringing another proof of that identity of heat and light, with radiations differing only in wave-length, long since surmised by physicists, and asserted prominently by Dr. John Draper, whose photographs are also the earliest in the path which Captain Abney has carried on by independent methods. Theoretically, there would seem to be no limit to this power of photography so long as objects radiate any heat whatever.

Of recent coronal studies, I have only to speak of the opportunity afforded by the eclipse of last year in our own Western territory. Observed as it was in the pure air of the Rocky Mountains, we found

an immense and hitherto almost unsuspected extension of the corona in the direction of the solar equator, such as to make it increasingly probable that the outer corona and the zodiacal light are different appearances with a common origin. The physical constitution of the inner corona seemed to be modified by the weakness or absence of a former constituent, and perhaps we may say that some additional knowledge was gained as to its telescopic structure and its absolute light, while the polariscopic evidence was contradictory.

In the light of our latest knowledge, what, then, is the corona? We do not know. We have literally had but about twenty minutes in the last twenty years to look at it, and from that brief study it remains every way problematical. The extent of this vast solar appendage is unknown, its constitution is unknown, its function is unknown, and it is still uncertain whether we can devise any means for its study which will free us from this dependence upon momentary glimpses. Our only hope, since the most powerful telescope is useless in our lower atmosphere, seems to be to transport our observatory to some mountain-height, like that of Etna or the elevated table-lands of Colorado. There, even, we can not be sure of seeing it without an eclipse; but there, if anywhere, ingenuity will be hopefully employed in an endeavor to remove the difficulties which bar the way. After spending some weeks this year myself upon Mount Etna, on which the new solar observatory is to be built, I can testify to the excellence of such a station; and yet, when we have sites equally good, I can not but regret that it should be left to others to first enter such a promising field.

Of recent spectro-photographic observation, I may mention the valuable work of M. Cornu, who, working at the other extremity of the spectrum from Captain Abney, has extended it beyond the violet to a wave-length of 2,900, far beyond which the solar spectrum probably exists, but where M. Cornu finds our own atmosphere to interpose an almost impassable barrier. The solar spectrum, therefore, is now known by photography through three times the extent of the visible portion, and this great gain on our former knowledge may be said to have been completed for us in the past year.

In last November and subsequently, Mr. Lockyer has made the extremely important announcement that, reasoning from analogies furnished by known compounds, he has been able to show that many elements are really compound bodies, which, incompletely dissociated at the highest temperatures we can command, furnish under the form of feeble lines the spectra of their components.

I do not enter here into discussion of points still in debate; but that which has arisen round this and the recent communications of Dr. Henry Draper, at any rate elicits the evidence of the immense labor now requisite in establishing new facts in our science, and the refinement of some of the adverse explanations suggested in contro-

versy shows us to how limited a company of specialists we must look as judges in matters so important.

The instrumental aids of our study have grown in the period under review with the demand for greater accuracy, until the detached prisms of Kirchhoff's apparatus are replaced by trains of automatically adjustable mechanism, giving us in Thollon's recent instrument the equivalent dispersion of thirty prisms of flint, or what has replaced the "gitter" of Fraunhofer, that wonderful product of skill, the Rutherfurd grating, which for a large variety of uses has already supplanted the prism. Observatories especially devoted to solar physics are being established by European governments, as at Potsdam by Prussia, and at Meudon by France. I have already alluded to that on Etna, and I hope it will not be long before we have a distinctly physical observatory within our own territory. There is no step in our power to take which promises so much for immediate advance as the installation of one in a suitably elevated station, for certain investigations can be made *only* under this condition, and no amount of instrumental appliance, patience, or skill, at a lower altitude, supplies their place.

In now reviewing the acquisitions which this twenty years' labor has brought us, we can not but agree that we have achieved a great deal, and yet must admit, with wonder at the field still before us, how little is our progress in comparison with what remains unknown.

We have found out how to detect daily the outbursts from the sun which were before invisible, but we watch these outpourings of enormous forms without yet knowing what drives them forth, without being sure how far our very view is not in part illusion.

We have learned how to study and fix many of the wonderful details of spot-actions without knowing what spots are. We see them presenting themselves in increasing importance through a term of years, and then diminishing, and we attempt to assign a period to these cycles of growth and decay. This period is often fixed at about eleven years, with a perhaps unjustifiable confidence, for we can not be said to know whether what we have seen in so brief a time is constant or variable, nor whether it be not the mere incident of some greater cycle, whose course began before man was here to see it, and whose term may not be complete till he has gone.

We are possibly now led to ask what our science has taught us on the connection of these remote changes with questions which affect our daily lives, and perhaps to put the utilitarian question, "What is all this worth?"

We find at the present time our study growing into a closer union, not merely with stellar astronomy on the one hand and terrestrial meteorology on the other, but with all the physical sciences, than would once have been supposed possible. Thus, to give a single instance, whatever be the result of the discussions aroused by Mr. Lockyer's statements, it seems likely that we are to look to the analysis of the

solar radiations for the most favorable evidence of that resolvability of our so-called elements to simpler forms, which our chemists are now very generally ready to admit as possible.

It is in the solar spectrum that we are now searching for the laws of the molecular groupings which affect the ultimate constitution of matter, and in recent questions as to the real nature of certain terrestrial elements, which our laboratories can not yet deal with, the Mount Sherman observations of Professor Young on the appearance of their analogues in the sun have been accepted by both parties in debates before the Royal Society, as pertinent evidence, the only doubt as to which lies in its interpretation.

Of problems "practical" in the sense that their utility is apparent alike to the learned and the unlearned, there are two at least of the highest importance which now occupy us.

The solar heat, which grows for us the food by which we live, is no doubt in one sense the final cause of every meteorological change, bringing those years of want and years of plenty which are due to local variations of climate, that depend, through a chain of causes very remote and obscure, no doubt, yet finally, upon the sun. We have seen the magnetic needles vibrating all over the globe together at the time of a sudden commotion upon the solar surface; we watch the increase and decrease of auroras, and find we can almost predict their frequency, so apparently united are they by some mysterious bond with the changes of solar spots; and we look with natural hope for other signs of union which may enable us to anticipate more important effects on our meteorology. Extreme pains have been devoted —in some cases misdevoted—to researches aiming to establish such a connection, by collecting data as to the changes in rainfall, the movements of storms, the prices of grain, and of almost every feature of terrestrial meteorology, in order to see whether these run through periods coincident with those of known changes on the solar surface. It will be admitted by the most utilitarian that the end aimed at is a worthy one, for the practical result of success, such as some believe possible, would be to enable its attainer to predict the price of breadstuffs years in advance, to control the markets of the world; to bestow, if unselfish, an almost priceless knowledge to man, or, if self-seeking, to acquire wealth beyond wish.

I need hardly say that the attempt has thus far been unsuccessful. There is hardly any topic on which there is more popular interest, hardly any on which there is more popular error, than this of the supposed influence of the sun on the weather. By means of the study of what Professor Smythe terms the "rain-band" in the spectrum, we appear to have lately gained increased facility in predicting local weather-changes; but, excepting this comparatively unimportant contribution, studies connected with the sun have as yet done very little for us here, and it seems necessary to say that, as far as prophecy is

concerned, none of us are yet prophets, or more able to tell from our knowledge of the sun what the weather will be next week than what the harvest will be next year.

There is another utilitarian aspect of our study about which there is less public interest, but more real promise—I mean that which concerns the direct application of solar heat to arts and manufactures. These are now all using it indirectly—by the water, for instance, which it lifts into the clouds to turn the mills of Lowell or Lawrence, as it flows back to the sea, or by the coal which it stored in former ages to drive our engines to-day. These indirect means use but the feeblest portion of the solar heat, which is in theory capable of furnishing nearly one horse-power for each square yard of the earth's surface under full sunshine.

What we have actually realized in experiment is still considerable. The visitor to the last Paris Exposition may have seen upon its grounds a machine of strange appearance, in the open air, pointing sunward the axis of an immense reflector, shaped like a truncated cone, which gathered the rays to a linear focus upon the boiler of a working steam-engine, which it drove thus by direct solar heat. Many not dissimilar solar engines have been built in this country and in India, the particular one of which I speak, due to M. Mouchot, having actually realized about one horse-power to ten feet square of surface.

We are startled when we make the computation, to find the immensity of the force thus placed at our disposal, or to see what the utilization of the waste places of the earth would bring us. Upon the limited area of the Adirondack wilderness to the north of us, for instance, the daily wasted sun-power actually realizable, and after every allowance for loss, is many times that of all the estimated steam-power at present in use in the whole world. I am not myself so far utilitarian as to wish to see this use made of our pleasant summer haunts, but there are regions of the earth at present as entirely worthless as that great African desert which it is now proposed to partly reconvert to an inland sea, a sunburned area now apparently hopelessly useless to man, and yet on which an amount of power is every year poured in utter waste which could not be made good by the consumption of all the coal known to underlie the soil of Great Britain.

Such machines as those of M. Mouchot, owing to the expense of construction and attendance, cost more than an engine driven by coal, though the sun supplies its power gratis; but it is simply, it seems to me, a question of time when, with another form which I believe our researches already indicate, such engines may become an economical as well as a mechanical success, and in a larger sense it is still only a question of time when the rapidly consuming coal-beds of Great Britain yield their last, and her manufacturing empire is transferred to countries which have not exhausted their supply. But these will exhaust their own in turn; the stock, though great, is finite and

not renewable; and we must look, for the only power we know which can replace coal, to those regions of the earth now desolated by solar heat, and to which future empire may probably tend.

We have considered the past and the present of our study; for its future, lies the solution of all the great problems I have already alluded to, but these questions are so interlocked that the complete answer to one will probably not be given till we are nearly ready to answer all.

I have spoken of the fallacy of the popular impression of the result of our study as enabling us to predict the weather, or to anticipate the character of coming harvests. Repeating my belief that we as yet know nothing here, or next to nothing, I yet do not mean to disparage the object of such researches, nor even to deny the possibility of their ultimate success. We can look forward, among other fair dreams for our science's future, to a time when it will enable us to predict the years of plenty or play the part of a beneficent Providence, by warning in season against those of famine, which have cost in our time so many million lives in China and in India. These are, I repeat, still dreams only, but we may call them hopes if we will—hopes of which increased knowledge may deprive us, but of which we can not say it may not bring fruition.

There remains among the greatest problems of the future of our science the all-important one to the whole human race of the future constancy of the sun's heat, of which we have, it seems to me, no assurance of the present rate of supply. We have, it is true, every assurance that in the contraction of the solar mass and in the supply of meteoric matter, we have heat to warm the human race for periods almost beyond limit; but we learn also that this heat is tempered to us by a solar envelope, which seems to be, as far as we know, in conditions which do not favor stability. It is constantly being added to by eruptions from within the sun, caused by we know not what, and constantly diminished by some counter-process which we understand as little. When we consider that the thickening of this solar atmosphere would bring back the age of ice, or its thinning carry our polar regions to tropical temperature, and when we remember that rhythmical action, not uniformity, seems to be the law of nature here, we can feel no certainty of the future constancy of the solar heat, nor of our protection against such changes as seem to have befallen other suns in space, and against which we are powerless to guard.

But such considerations of our ignorance and helplessness, while they may prevent us from any undue pride in what our science has already attained, may teach us renewed confidence from the very brevity of our life. These green fields around us were once covered with glacial ice, and the change has been absolute from that condition to the one of to-day. Yet in the lifetime of any one of the thousands of insect generations which have succeeded each other in these fields,

there must have seemed no alteration; and, remembering what instants our own lives are, in a like comparison with the uncounted ages of the sun's history, we may well reckon that our generation shall see no change.

In the little span which is allowed us, however, we will try to learn something more of that source of light, life, and power of which we are materially the creatures; and, if we can leave a knowledge which will not die with ourselves, feel that we have left also the record of a something in us "which owes no homage to the sun."

THE DISEASES OF WILD ANIMALS.*

By Professor JEAN VILAIN.

SOME naturalists have asserted that wild animals, when in a state of liberty, are almost entirely free from disease, and that the latter afflicts them only when in captivity. I know that this is entirely erroneous, and it can be proved that captive wild animals are more exempt from ailments than those roaming at large.

While First Surgeon of the Thirty-first Regiment of the Line, then stationed at Alabera, in Algeria, I dissected the carcasses of about fifty lions. The lungs of twenty of them were affected; one half of them were almost gone, showing that consumption is prevalent among the lions of the Sahara and the Sahel.

At the Jardin des Plantes, here in Paris, seven lions have died since 1869. All of them were born here. I dissected them, and found that their lungs were entirely healthy. To what was the difference due? They received their food regularly, and were carefully protected from inclement weather, while the lions in Africa had to go without food for days, had to inhale the sandy air of the desert, and were frequently drenched by terrible rains.

There is at the Jardin des Plantes a wolf from the Ardennes. He was caught when about six years old. He was suffering from cough, and at one time we thought he was dying. He hawked and spat, and was always sullen and morose. Often he abstained from food for several days. At last we chloroformed him, and examined his throat. He was found to be suffering from nasal catarrh in its most aggravated form. Under proper medical treatment he recovered rapidly. Nine wolves born at the Jardin never showed the slightest sign of disease.

M. Jacquemart, the famous Indian hunter, often told me that he had seen tigers spitting blood, which exhausted them so that they could be approached within a few feet with impunity.

* Translated from the "Revue Zoölogique."

All monkeys are very delicate animals. They are not gluttonous; and having so much exercise, they are rarely afflicted with diseases of the bowels. But they have weak lungs, and the reason why so many of the most interesting among them die when brought to Europe is the too sudden change of air, diet, and water. There is no more intelligent monkey than the chimpanzee, a truly wonderful animal. While in Berlin I dined at the Zoölogical Gardens by the side of a pet chimpanzee. He partook of every dish like a human being, put sugar into his teacup, stirred it with the spoon, and drank the beverage with evident relish. But his eyes looked supernaturally bright. I felt his pulse. It was 125. "He will not live long," I said to his keeper.

"Why not?" he asked with a sorrowful mien.

"He is consumptive," I replied.

"Indeed! He often coughs."

The chimpanzee died a month later. His left lung was entirely gone.

Carnivorous animals suffer from digestive disorders only when fed upon poor meat. I dissected three hyenas: two in Paris, one in London. Their bowels presented an entirely healthy appearance, and so did their stomachs. But the reverse was the case of an old Abyssinian hyena belonging to a Greek menagerie-keeper, who had caught the animal himself in Africa. He managed to keep it alive for two years, but told me: "The beast always vomited, and often lay on the ground, moaning piteously. What was the cause?" I dissected the hyena. The stomach was in a terrible condition. It was dotted with the scars of boils.

Dogs are gluttons. Wild dogs are worse. We have at the Jardin one of these able to devour meat enough to gorge a tiger or a lion; but the animal has to pay dearly for its voracity; it is always suffering from aggravated constipation, and will not live long.

Foxes are shrewd about everything, and so they are about their food. What hunter has ever found a fox that died from disease? Zoölogists admire the dissected body of a fox because there is never anything unhealthy to be found in its organs. Hence, foxes are long-lived.

Six months ago we received at the Jardin four buffaloes from the North American Plains. Two of them died three days after their arrival. They were found to be suffering from a multiplicity of diseases—dyspepsia, imperfect action of the kidneys, and fatty degeneration of the heart. The other two have been ailing ever since, and yet the young buffalo born at the Zoölogical Gardens of Cologne is the embodiment of health.

The elephant is one of the most temperate and abstemious of animals. He eats for his size so little food that it is a wonder how he is able to exist upon it. True, he dies in captivity before his time, but not from physical causes. There is no doubt that he is one of the

most sensitive of animals. A slight or a disappointment mortifies him deeply. The elephants of South Africa, which are rough animals when compared with those raised in captivity, die from diarrhœa or constipation, as Le Vaillant has stated. Their tamer brethren are free from disease; and, if they die before their time, they generally do so from the above-mentioned causes. Sultan, the pride of the Jardin, the most amiable elephant I ever knew, was unable to survive the death of his companion, the pet dog Jean.

ON RADIANT MATTER.*

By WILLIAM CROOKES, F. R. S.

I.

TO throw light on the title of this lecture I must go back more than sixty years—to 1816. Faraday, then a mere student and ardent experimentalist, was twenty-four years old, and at this early period of his career he delivered a series of lectures on the general properties of matter, and one of them bore the remarkable title, "On Radiant Matter." The great philosopher's notes of this lecture are to be found in Dr. Bence Jones's "Life and Letters of Faraday," and I will here quote a passage in which he first employs the expression *radiant matter:*

> If we conceive a change as far beyond vaporization as that is above fluidity, and then take into account also the proportional increased extent of alteration as the changes rise, we shall perhaps, if we can form any conception at all, not fall far short of radiant matter; and as in the last conversion many qualities were lost, so here also many more would disappear.

Faraday was evidently engrossed with this far-reaching speculation, for three years later—in 1819—we find him bringing fresh evidence and argument to strengthen his startling hypothesis. His notes are now more extended, and they show that in the intervening three years he had thought much and deeply on this higher form of matter. He first points out that matter may be classed into four states—solid, liquid, gaseous, and radiant—these modifications depending upon differences in their several essential properties. He admits that the existence of radiant matter is as yet unproved, and then proceeds, in a series of ingenious analogical arguments, to show the probability of its existence.†

* A lecture delivered before the British Association for the Advancement of Science, at Sheffield, Friday, August 22, 1879.

† I may now notice a curious progression in physical properties accompanying changes of form, and which is perhaps sufficient to induce, in the inventive and sanguine philoso-

If, in the beginning of this century, we had asked, What is a gas? the answer then would have been that it is matter, expanded and rarefied to such an extent as to be impalpable, save when set in violent motion; invisible, incapable of assuming or of being reduced into any definite form like solids, or of forming drops like liquids; always ready to expand where no resistance is offered, and to contract on being subjected to pressure. Sixty years ago such were the chief attributes assigned to gases. Modern research, however, has greatly enlarged and modified our views on the constitution of these elastic fluids. Gases are now considered to be composed of an almost infinite number of small particles or molecules, which are constantly moving in every direction with velocities of all conceivable magnitudes. As these molecules are exceedingly numerous, it follows that no molecule can move far in any direction without coming in contact with some other molecule. But if we exhaust the air or gas contained in a closed vessel, the number of molecules becomes diminished, and the distance through which any one of them can move without coming in contact with another is increased, the length of the mean free path being inversely proportional to the number of molecules present. The further this process is carried the longer becomes the average distance a molecule can travel before entering into collision; or, in other words, the longer its mean free path, the more the physical properties of the gas or air are modified. Thus, at a certain point, the phenomena of the radiometer become possible, and on pushing the rarefaction still further—i. e., decreasing the number of molecules in a given space and lengthening their mean free path—the experimental results are obtain-

pher, a considerable degree of belief in the association of the radiant form with the others in the set of changes I have mentioned.

As we ascend from the solid to the fluid and gaseous states, physical properties diminish in number and variety, each state losing some of those which belonged to the preceding state. When solids are converted into fluids, all the varieties of hardness and softness are necessarily lost. Crystalline and other shapes are destroyed. Opacity and color frequently give way to a colorless transparency, and a general mobility of particles is conferred.

Passing onward to the gaseous state, still more of the evident characters of bodies are annihilated. The immense differences in their weight almost disappear; the remains of difference in color that were left are lost. Transparency becomes universal, and they are all elastic. They now form but one set of substances, and the varieties of density, hardness, opacity, color, elasticity, and form, which render the number of solids and fluids almost infinite, are now supplied by a few slight variations in weight, and some unimportant shades of color.

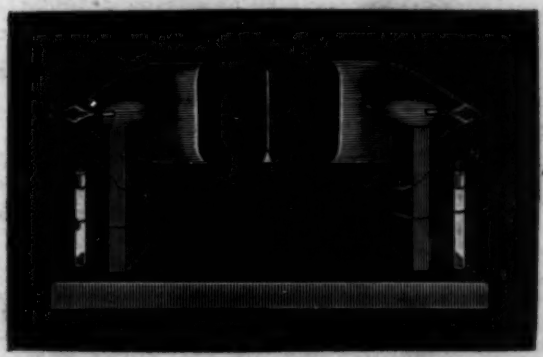
To those, therefore, who admit the radiant form of matter, no difficulty exists in the simplicity of the properties it possesses, but rather an argument in their favor. These persons show you a gradual resignation of properties in the matter we can appreciate as the matter ascends in the scale of forms, and they would be surprised if that effect were to cease at the gaseous state. They point out the greater exertions which Nature makes at each step of the change, and think that, consistently, it ought to be greatest in the passage from the gaseous to the radiant form.—("Life and Letters of Faraday," vol. i., p. 308.)

able to which I am now about to call your attention. So distinct are these phenomena from anything which occurs in air or gas at the ordinary tension, that we are led to assume that we are here brought face to face with matter in a fourth state or condition, a condition as far removed from the state of gas as a gas is from a liquid.

Mean Free Path—Radiant Matter.—I have long believed that a well-known appearance observed in vacuum-tubes is closely related to the phenomena of the mean free path of the molecules. When the negative pole is examined while the discharge from an induction coil is passing through an exhausted tube, a dark space is seen to surround it. This dark space is found to increase and diminish as the vacuum is varied, in the same way that the mean free path of the molecules lengthens and contracts. As the one is perceived by the mind's eye to get greater, so the other is seen by the bodily eye to increase in size; and, if the vacuum is insufficient to permit much play of the molecules before they enter into collision, the passage of electricity shows that the "dark space" has shrunk to small dimensions. We naturally infer that the dark space is the mean free path of the molecules of the residual gas, an inference confirmed by experiment.

I will endeavor to render this "dark space" visible to all present. Here is a tube (Fig. 1), having a pole in the center in the form of a

FIG 1.



metal disk, and other poles at each end. The center pole is made negative, and the two end poles connected together are made the positive terminal. The dark space will be in the center. When the exhaustion is not very great, the dark space extends only a little on each side of the negative pole in the center. When the exhaustion is good, as in the tube before you, and I turn on the coil, the dark space is seen to extend for about an inch on each side of the pole.

Here, then, we see the induction-spark actually illuminating the lines of molecular pressure caused by the excitement of the negative pole. The thickness of this dark space is the measure of the mean free

path between successive collisions of the molecules of the residual gas. The extra velocity with which the negatively electrified molecules rebound from the excited pole keeps back the more slowly moving molecules which are advancing toward that pole. A conflict occurs at the boundary of the dark space, where the luminous margin bears witness to the energy of the discharge.

Therefore the residual gas—or, as I prefer to call it, the gaseous residue—within the dark space is in an entirely different state to that of the residual gas in vessels at a lower degree of exhaustion. To quote the words of our last year's President, in his address at Dublin:

> In the exhausted column we have a vehicle for electricity not constant like an ordinary conductor, but itself modified by the passage of the discharge, and perhaps subject to laws differing materially from those which it obeys at atmospheric pressure.

In the vessels with the lower degree of exhaustion, the length of the mean free path of the molecules is exceedingly small as compared with the dimensions of the bulb, and the properties belonging to the ordinary gaseous state of matter, depending upon constant collisions, can be observed. But in the phenomena now about to be examined, so high is the exhaustion carried that the dark space around the negative pole has widened out till it entirely fills the tube. By great rarefaction the mean free path has become so long that the hits in a given time in comparison to the misses may be disregarded, and the average molecule is now allowed to obey its own motions or laws without interference. The mean free path, in fact, is comparable to the dimensions of the vessel, and we have no longer to deal with a *continuous* portion of matter, as would be the case were the tubes less highly exhausted, but we must here contemplate the molecules *individually*. In these highly exhausted vessels the molecules of the gaseous residue are able to dart across the tube with comparatively few collisions, and

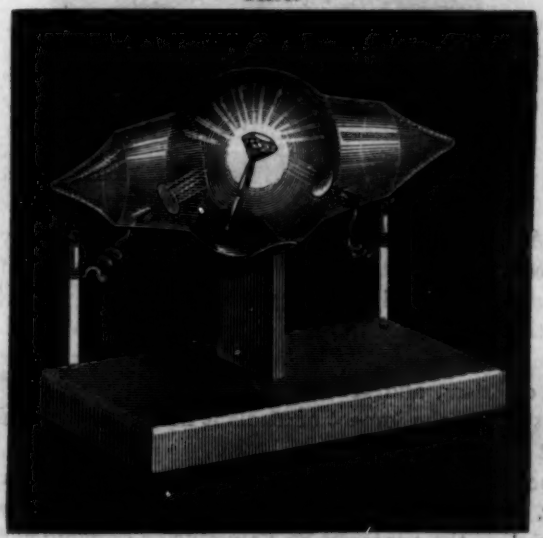
FIG. 2.

radiating from the pole with enormous velocity, they assume properties so novel and so characteristic as to entirely justify the application of the term borrowed from Faraday, that of *radiant matter*.

• *Radiant Matter exerts Powerful Phosphorogenic Action where it strikes.*—I have mentioned that the radiant matter within the dark space excites luminosity where its velocity is arrested by residual gas outside the dark space. But if no residual gas is left, the molecules will have their velocity arrested by the sides of the glass; and here we come to the first and one of the most noteworthy properties of radiant matter discharged from the negative pole—its power of exciting phosphorescence when it strikes against solid matter. The number of bodies which respond luminously to this molecular bombardment is very great, and the resulting colors are of every variety. Glass, for instance, is highly phosphorescent when exposed to a stream of radiant matter. Here (Fig. 2) are three bulbs composed of different glass: one is uranium glass (*a*), which phosphoresces of a dark-green color; another is English glass (*b*), which phosphoresces of a blue color; and the third (*c*) is soft German glass—of which most of the apparatus before you is made—which phosphoresces of a bright apple-green.

My earlier experiments were almost entirely carried on by the aid of the phosphorescence which glass takes up when it is under the influence of the radiant discharge; but many other substances possess this

FIG. 3.

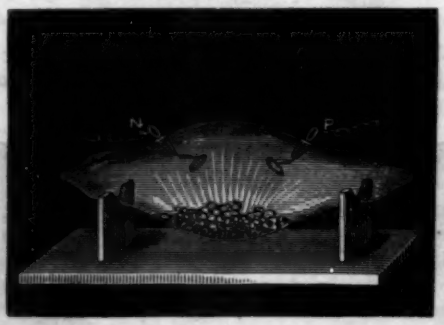


phosphorescent power in a still higher degree than glass. For instance, here is some of the luminous sulphide of calcium prepared according to M. Ed. Becquerel's description. When the sulphide is exposed to light—even candle-light—it phosphoresces for hours with a bluish-white color. It is, however, much more strongly phosphorescent to the molecular discharge in a good vacuum, as you will see when I pass the discharge through this tube.

Other substances besides English, German, and uranium glass, and Becquerel's luminous sulphides, are also phosphorescent. The rare mineral Phenakite (aluminate of glucinum) phosphoresces blue; the mineral Spodumene (a silicate of aluminium and lithium) phosphoresces a rich golden yellow; the emerald gives out a crimson light. But, without exception, the diamond is the most sensitive substance I have yet met for ready and brilliant phosphorescence. Here is a very curious fluorescent diamond, green by daylight, colorless by candle-light. It is mounted in the center of an exhausted bulb (Fig. 3), and the molecular discharge will be directed on it from below upward. On darkening the room you see the diamond shines with as much light as a candle, phosphorescing of a bright green.

Next to the diamond the ruby is one of the most remarkable stones for phosphorescing. In this tube (Fig. 4.) is a fine collection of ruby-

FIG. 4.



pebbles. As soon as the induction-spark is turned on, you will see these rubies shining with a brilliant rich red tone, as if they were glowing hot. It scarcely matters what color the ruby is, to begin with. In this tube of natural rubies there are stones of all colors—the deep-red and also the pale-pink ruby. There are some so pale as to be almost colorless, and some of the highly prized tint of pigeon's blood; but under the impact of radiant matter they all phosphoresce with about the same color.

Now the ruby is nothing but crystallized alumina with a little coloring-matter. In a paper by Ed. Becquerel,* published twenty years ago, he describes the appearance of alumina as glowing with a rich red color in the phosphoroscope. Here is some precipitated alumina prepared in the most careful manner. It has been heated to whiteness, and you see it also glows under the molecular discharge with the same rich red color.

The spectrum of the red light emitted by these varieties of alumina is the same as described by Becquerel twenty years ago. There is one

* "Annales de Chimie et de Physique," third series, vol. lvii., p. 50, 1859.

intense red line, a little below the fixed line B in the spectrum, having a wave-length of about 6,895. There is a continuous spectrum beginning at about B, and a few fainter lines beyond it, but they are so faint in comparison with this red line that they may be neglected. This line is easily seen by examining with a small pocket spectroscope the light reflected from a good ruby.

There is one particular degree of exhaustion more favorable than any other for the development of the properties of radiant matter which are now under examination. Roughly speaking it may be put at the millionth of an atmosphere.* At this degree of exhaustion the phosphorescence is very strong, and after that it begins to diminish until the spark refuses to pass. †

I have here a tube, Fig. 5, which will serve to illustrate the dependence of the phosphorescence of the glass on the degree of exhaus-

* 1·0 millionth of an atmosphere = 0·00076 millim.
1315·789 millionths of an atmosphere = 1·0 millim.
1,000,000 " " " = 760·0 millims.
" " " " = 1 atmosphere.

† Nearly a hundred years ago, Mr. William Morgan communicated to the Royal Society a paper entitled "Electrical Experiments made to ascertain the Non-conducting Power of a Perfect Vacuum," etc. The following extracts from this paper, which was published in the "Philosophical Transactions" for 1785 (vol. lxxv., p. 272), will be read with interest:

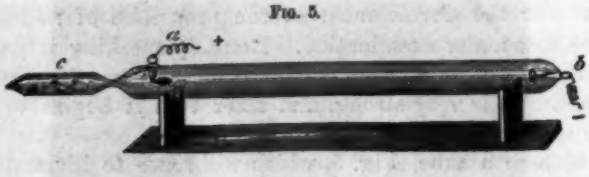
A mercurial gage about fifteen inches long, carefully and accurately boiled till every particle of air was expelled from the inside, was coated with tin-foil five inches down from its sealed end, and being inverted into mercury through a perforation in the brass cap which covered the mouth of the cistern, the whole was cemented together, and the air was exhausted from the inside of the cistern, through a valve in the brass cap, which, producing a perfect vacuum in the gage, formed an instrument peculiarly well adapted for experiments of this kind. Things being thus adjusted (a small wire having been previously fixed on the inside of the cistern to form a communication between the brass cap and the mercury, into which the gage was inverted), the coated end was applied to the conductor of an electrical machine, and, notwithstanding every effort, neither the smallest ray of light, nor the slightest charge, could ever be procured in this exhausted gage.

If the mercury in the gage be imperfectly boiled, the experiment will not succeed; but the color of the electric light, which in air rarefied by an exhauster is always violet or purple, appears in this case of a beautiful green, and, what is very curious, the degree of the air's rarefaction may be nearly determined by this means; for I have known instances, during the course of these experiments, where a small particle of air having found its way into the tube, the electric light became visible, and as usual of a green color; but the charge being often repeated, the gage has at length cracked at its sealed end, and in consequence the external air, by being admitted into the inside, has gradually produced a change in the electric light from green to blue, from blue to indigo, and so on to violet and purple, till the medium has at length become so dense as no longer to be a conductor of electricity. I think there can be little doubt, from the above experiments, of the non-conducting power of a perfect vacuum.

This seems to prove that there is a limit even in the rarefaction of air, which sets bounds to its conducting power; or, in other words, that the particles of air may be so far separated from each other as no longer to be able to transmit the electric fluid; that if they are brought within a certain distance of each other, their conducting power begins, and continually increases till their approach also arrives at its limit.

tion. The two poles are at *a* and *b*, and at the end *c* is a small supplementary tube, connected with the other by a narrow aperture, and containing solid caustic potash. The tube has been exhausted to a very high point, and the potash heated so as to drive off moisture and injure the vacuum. Exhaustion has then been recommenced, and the alternate heating and exhaustion repeated until the tube has been

FIG. 5.



brought to the state in which it now appears before you. When the induction spark is first turned on nothing is visible—the vacuum is so high that the tube is non-conducting. I now warm the potash slightly and liberate a trace of aqueous vapor. Instantly conduction commences, and the green phosphorescence flashes out along the length of the tube. I continue the heat, so as to drive off more gas from the potash. The green gets fainter, and now a wave of cloudy luminosity sweeps over the tube, and stratifications appear, which rapidly get narrower, until the spark passes along the tube in the form of a narrow purple line. I take the lamp away, and allow the potash to cool; as it cools, the aqueous vapor, which the heat had driven off, is reabsorbed. The purple line broadens out, and breaks up into fine stratifications; these get wider, and travel toward the potash-tube. Now a wave of green light appears on the glass at the other end, sweeping on and driving the last pale stratification into the potash; and now the tube glows over its whole length with the green phosphorescence. I might keep it before you, and show the green growing fainter and the vacuum becoming non-conducting; but I should detain you too long, as time is required for the absorption of the last traces of vapor by the potash, and I must pass on to the next subject.

Radiant Matter proceeds in Straight Lines.—The radiant matter whose impact on the glass causes an evolution of light, absolutely refuses to turn a corner. Here is a V-shaped tube (Fig. 6), a pole being at each extremity. The pole at the right side (*a*) being negative, you see that the whole of the right arm is flooded with green light, but at the bottom it stops sharply and will not turn the corner to get into the left side. When I reverse the current and make the left pole negative, the green changes to the left side, always following the negative pole and leaving the positive side with scarcely any luminosity.

In the ordinary phenomena exhibited by vacuum-tubes—phenomena with which we are all familiar—it is customary, in order to bring out the striking contrasts of color, to bend the tubes into very elaborate designs. The luminosity caused by the phosphorescence of the residual

gas follows all the convolutions into which skillful glass-blowers can manage to twist the glass. The negative pole being at one end and the positive pole at the other, the luminous phenomena seem to depend more on the positive than on the negative at the ordinary exhaus-

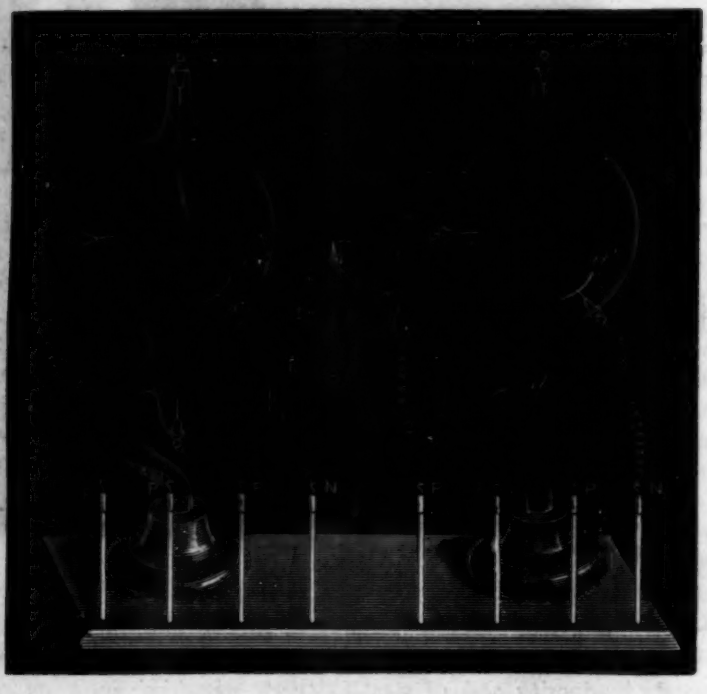
FIG. 6.

tion hitherto used to get the best phenomena of vacuum-tubes. But at a very high exhaustion the phenomena noticed in ordinary vacuum tubes when the induction-spark passes through them—an appearance of cloudy luminosity and of stratifications—disappear entirely. No cloud or fog whatever is seen in the body of the tube, and with such a vacuum as I am working with in these experiments, the only light observed is that from the phosphorescent surface of the glass. I have here two bulbs (Fig. 7), alike in shape and position of poles, the only difference being that one is at an exhaustion equal to a few millimetres of mercury—such a moderate exhaustion as will give the ordinary luminous phenomena—while the other is exhausted to about the millionth of an atmosphere. I will first connect the moderately exhausted bulb (A) with the induction-coil, and retaining the pole at one side (*a*) always negative, I will put the positive wire successively to the other poles with which the bulb is furnished. You see that as I change the position of the positive pole, the line of violet light joining the two poles changes, the electric current always choosing the shortest path between the two poles, and moving about the bulb as I alter the position of the wires.

This, then, is the kind of phenomenon we get in ordinary exhaus-

tions. I will now try the same experiment with a bulb (B) that is very highly exhausted, and, as before, will make the side pole (*a'*) the negative, the top pole (*b*) being positive. Notice how widely different is the appearance from that shown by the last bulb. The negative pole is in the form of a shallow cup. The molecular rays from the

FIG. 7.



cup cross in the center of the bulb, and thence diverging fall on the opposite side and produce a circular patch of green, phosphorescent light. As I turn the bulb round you will all be able to see the green patch on the glass. Now, observe, I remove the positive wire from the top, and connect it with the side pole (*c*). The green patch from the divergent negative focus is there still. I now make the lowest pole (*d*) positive, and the green patch remains where it was at first, unchanged in position or intensity.

We have here another property of radiant matter. In the low vacuum the position of the positive pole is of every importance, while in a high vacuum the position of the positive pole scarcely matters at all; the phenomena seem to depend entirely on the negative pole. If the negative pole points in the direction of the positive, all very well, but if the negative pole is entirely in the opposite direction it is of little consequence; the radiant matter darts all the same in a straight line from the negative.

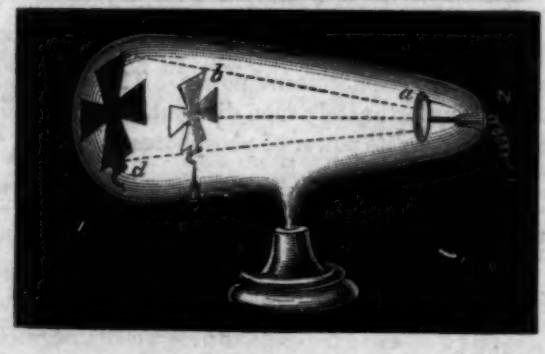
If, instead of a flat disk, a hemi-cylinder is used for the negative pole, the matter still radiates normal to its surface. The tube before you (Fig. 8) illustrates this property. It contains, as a negative pole, a hemi-cylinder (*a*) of polished aluminium. This is connected with a fine copper wire, *b*, ending at the platinum terminal, *c*. At the upper end of the tube is another terminal, *d*. The induction-coil is connected so that the hemi-cylinder is negative and the upper pole positive, and when exhausted to a sufficient extent the projection of the molecular rays to a focus is very beautifully shown. The rays of matter being driven from the hemi-cylinder in a direction normal to its surface, come to a focus and then diverge, tracing their path in brilliant green phosphorescence on the surface of the glass.

FIG. 8.

Instead of receiving the molecular rays on the glass, I will show you another tube in which the focus falls on a phosphorescent screen. See how brilliantly the lines of discharge shine out, and how intensely the focal point is illuminated, lighting up the table.

Radiant Matter when intercepted by Solid Matter casts a Shadow.—Radiant matter comes from the pole in straight lines, and does not merely permeate all parts of the tube and fill it with light, as would

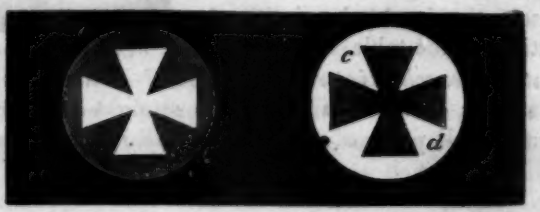
FIG. 9.



be the case were the exhaustion less good. Where there is nothing in the way the rays strike the screen and produce phosphorescence, and where solid matter intervenes they are obstructed by it, and a shadow

is thrown on the screen. In this pear-shaped bulb (Fig. 9) the negative pole (*a*) is at the pointed end. In the middle is a cross (*b*) cut out of sheet-aluminium, so that the rays from the negative pole projected along the tube will be partly intercepted by the aluminium cross, and will project an image of it on the hemispherical end of the tube which is phosphorescent. I turn on the coil, and you will all see the black shadow of the cross on the luminous end of the bulb (*c*, *d*). Now, the radiant matter from the negative pole has been passing by the side of the aluminium cross to produce the shadow ; the glass has been hammered and bombarded till it is appreciably warm, and at the same time another effect has been produced on the glass—its sensibility has been deadened. The glass has got tired, if I may use the expression, by the enforced phosphorescence. A change has been produced by this molecular bombardment which will prevent the glass from responding easily to additional excitement ; but the part that the shadow has fallen on is not tired—it has not been phosphorescing at all and is perfectly fresh ; therefore, if I throw down this cross—I can easily do so by giving the apparatus a slight jerk, for it has been most ingeniously constructed with a hinge by Mr. Gimingham—and so allow the rays from the negative pole to fall uninterruptedly on to the end of the bulb, you will suddenly see the black cross (*c*, *d*, Fig. 10) change to a luminous one (*e*, *f*), because the background is now only capable

FIG. 10.



of faintly phosphorescing, while the part which had the black shadow on it retains its full phosphorescent power. The stenciled image of the luminous cross unfortunately soon dies out. After a period of rest the glass partly recovers its power of phosphorescing, but it is never so good as it was at first.

Here, therefore, is another important property of radiant matter. It is projected with great velocity from the negative pole, and not only strikes the glass in such a way as to cause it to vibrate and become temporarily luminous while the discharge is going on, but the molecules hammer away with sufficient energy to produce a permanent impression upon the glass.

JOHN STUART MILL.

By ALEXANDER BAIN, LL. D.,
PROFESSOR OF LOGIC IN THE UNIVERSITY OF ABERDEEN.

IV.

THE year 1842 was memorable for the American repudiation, in which Mill was heavily involved. He had invested, I am told, a thousand pounds of his own money, and several thousands of his father's money which he had in trust for the family, and which he would have to make good. The blow completely shook him for the time. From whatever cause, or union of causes, his bodily strength was prostrated to such degree that, before I left London that autumn, he was unequal to his usual walk from the India House home, and took the omnibus before he went far. The disaster must have preyed upon him for a year or more. He alluded to his state in the Comte letters, in which he described his depression as both physical and moral. It appears that in a letter to Comte of the 15th of November, he gave assurances of his being much better. So in writing to me on the 3d of October, he says, "I am quite well and strong, and now walk the whole way to and from Kensington without the self-indulgence of omni*bi*." But on the 5th of December he says, "I have not been very well, but am a little better." He was now in the middle of the very heavy winter's work of getting the "Logic" through the press. There is no more heard of his health till the following June, in which he wrote to Comte in a very depressed tone. I remember, either in that or in the previous summer, his confessing to me that he was in a low state. I naturally urged that he had a long continuance of very heavy work. He replied hastily, "I do not believe any man was ever the worse for work," or something to that effect. I listened in mute astonishment, being quite ignorant that other circumstances besides his intellectual strain were at work. In writing to Comte, who, unlike him, believed in the bad consequences of prolonged study, he said his doctors advised him to rest his brain, but, as they knew so very little, he preferred to abide by his own feelings, which taught him that work was the only thing to counteract melancholy. Comte, however, urged that a "true *positive* therapeutics" involved rest and diversion; and Mill believed in regular holiday tours. It was during this dreadful depression of June and July, 1843, and after the American repudiation had beggared him, that he made his offer of pecuniary assistance to Comte. He had had no holiday for two years, and, except for his customary Sunday walks, he did not leave town that autumn: I suspect that his money affairs had something to do with his still postponing his holiday. In October his letters announce an improved state of health.

His work in 1843, after the publication of the "Logic," was his "Michelet" article, written in autumn. In September he writes: "I am now vigorously at work reviewing Michelet's 'History of France' for the 'Edinburgh.' I hope to *do* Napier, and get him to insert it before he finds out what a fatal thing he is doing." On November 3d he says: "My review of Michelet is in Napier's hands. If he prints it, he will make some of his readers stare." The article appeared in January, and had none of the serious consequences predicted. We have a difficulty, reading it now, to see anything very dreadful in its views. But a philosophic vindication of the Papacy and the celibacy of the clergy, as essential preservatives against barbarism, was not then familiar to the English mind. Mill had worked himself into sympathy with everything French, and echoed the importance of France from the French historians. He always dealt gently with her faults and liberally with her virtues.

While writing this article, he was projecting in his mind his next book, which was to be on the new science, first sketched in the "Logic," to be called "Ethology." With parental fondness, he cherished this subject for a considerable time; regarding it as the foundation and corner-stone of Sociology. "There is no chance," he says, "for social statics, at least until the laws of human character are better treated." A few months later he wrote: "I do not know when I shall be ripe for beginning 'Ethology.' The scheme has not assumed any definite shape with me yet." In fact, it never came to anything; and he seems shortly to have dropped thinking of it. I do not believe there was anything to be got in the direction that he was looking. He was all his life possessed of the idea that differences of character, individual and national, were due to accidents and circumstances that might possibly be, in part, controlled; on this doctrine rested his chief hope in the future. He would not allow that human beings at birth are so very different as they afterward turn out.

His failure with "Ethology" fatally interfered with the larger project, which I have no doubt he entertained, of executing a work on Sociology as a whole. The opinion was long afloat in London that he had such a work in view; but I do not think he ever said so; it was not his way to give out what he was engaged upon, at least before making himself sure of going through with it. That he despaired, for the present at least, of making anything out of "Ethology," at the time I refer to, is proved by his betaking himself soon after to the composition of his "Political Economy."

I have now disposed of all my memoranda relating to 1842 and 1843. The beginning of 1844 saw the publication of the article on Michelet to which I have adverted. In a letter dated 8th of January, I find this upon Beneke: "I am reading a German professor's book on Logic—Beneke is his name—which he has sent to me after reading mine, and which had previously been recommended to me by Austin

and by Herschel as in accordance with the spirit of my doctrines. It is so in some degree, though far more psychological than entered into my plans. Though I think much of his psychology unsound for want of his having properly grasped the principle of association (he comes very close to it now and then), there is much of it of a suggestive kind."

From the Comte letters it appears that he had another relapse of his indisposition at this time. Comte earnestly urges him to try a change of climate—Naples or Lisbon—to fortify him for the next few years against "le séjour *spleenique* de Londres." "What is the opinion, I do not say of your doctors, whom you have little faith in, but of those of your friends who are *biologists?*"

I passed three months in London in the summer of 1844, and saw him frequently as before. I have no special recollections of his work this summer. In the autumn he took his long-deferred holiday, and was absent from London two months. He came back quite recruited, and in the course of the winter wrote his admirable article on "The Claims of Labor," which appeared in the "Edinburgh" in the following spring.

I had several letters from him in the winter of 1844–'45, but they say little about himself. He remarks of the review of his "Logic" in the "Eclectic Review," that the reviewer differs from him on the Syllogism which he understands, and agrees with him on the rest of the book without seeming to understand it. He announces with satisfaction, as a most important conquest for Comte, the appearance of Littré's papers in the "National" newspaper. This, however, was immediately followed by his renewed and final exclusion from the Polytechnic examinership; for which one resource was suggested—to start a Positive Review; a scheme that bulks largely in the correspondence for some months, and receives from Mill a qualified support. In March, 1845, he writes to me: "Have you seen Ward's book, 'The Ideal,' etc.? It is a remarkable book in every way, and not the least so because it quotes and puffs me in every chapter, and Comte occasionally, though with deep lamentations over our irreligion." The Comte correspondence shows that he had written to Comte informing him of Mr. Ward's allusions. Comte is very much flattered, and thinks the compliments deserved, because of the justice he had rendered to Catholicism (p. 323).

The summer of 1845 was marked by an interesting incident. In June the British Association met at Cambridge, Sir John Herschel in the chair. I was at the meeting, and listened to Herschel's address. One notable feature in it was the allusion to the recent works on the "Logic of Science," by Whewell and Mill especially, on both of whom Sir John bestowed high encomiums. He also mentioned Comte, but in a very different strain. There was, I remember, a good deal of buzz among Mill's friends that were present, at this unexpected men-

tion of him. Mill was of course extremely gratified on his own account, but considered that Comte was very unfairly handled. Herschel brought up the nebular hypothesis, as advocated by Comte, but treated Comte's mathematics with contempt, and spoke of his book as "a philosophical work of much mathematical pretension, which has lately come into a good deal of notice in this country." To dismiss Comte in this summary fashion, even supposing he had laid himself open by his supposed mathematical proofs of the hypothesis, was a little too strong. Mill naturally thought it an evidence of some weakness in Herschel's mind that he should be so blind to the abundant manifestations of intellectual force in the "Philosophie Positive."* He wrote to Herschel, thanking him for the mention of himself, and remonstrating on his treatment of Comte; but went a little out of his depth in attempting to uphold Comte's calculation. Herschel, in replying, reiterated his approval of the "Logic," stating that it was his intention to have reviewed it in the "Quarterly," as he had done Whewell; but as regarded Comte, he was obdurate, and demolished at a stroke the proof that Mill had relied upon. I think Mill wrote a rejoinder. It is to be hoped that these letters are preserved. Mill copied them and sent them to Comte. It was not the first time that Herschel's name had come up between them; he must have previously written to Mill in acknowledgment of the "Logic." In Comte's letter of date 21st October, 1844 (p. 276), he refers to the information given him by Mill, that Herschel meant to read "mon grand ouvrage," but does not count upon its making a favorable impression, "du moins intense." He then gives the reasons: one being Herschel's prepossessions in favor of sidereal astronomy; the other his analogy to Arago, although "without the charlatanism and immorality of that disastrous personage." Such was the previous reference. The result of his seeing the present correspondence appears on page 362. Comte is very much touched with the zeal displayed by Mill on his behalf; but declines Mill's suggestion that he should himself take up the cudgels in his own defense. Mill, he says, had sufficiently proved, although in a polished way, the malevolent spirit and even the bad faith of Herschel. He is, however, quite satisfied with his former explanation of Herschel's motives, namely, the soreness caused by his discarding sidereal astronomy, on which Herschel's father and himself rested their chief fame.

In the summer of 1845 I became personally acquainted with Grote. For several years previously, Mill appears to have seen little of him,

* The following sentence in Mill's review of "Comte and Positivism" does not apply to the scientific magnates of England, at the date of Herschel's address: "He" (Comte) "has displayed a quantity and quality of mental power, and achieved an amount of success, which have not only won but retained the high admiration of thinkers as radically and strenuously opposed as it is possible to be to nearly the whole of his later tendencies, and to many of his earlier opinions."

but they had now resumed their footing of intimacy. Grote was living chiefly in the country, but when he came into town he made a point of arranging walks and talks with Mill. From the time of my introduction to Grote, I was usually asked to join them. I remember well our first meeting at the London Library, and subsequent walk in Hyde Park. Their conversation took an exceptional turn; how it came I can not exactly remember, but they went over all the leaders of the Reformation, discussing their several characteristics. The subject was not one that either was specially informed upon. As Grote was then on the eve of bringing out the first two volumes of his "History," this was a natural topic; but much more so, after the volumes were out. But Grote was never satisfied if we parted without coming across some question in metaphysics or philosophy. Although his time was mainly given to the "History," he always refreshed his mind at intervals with some philosophic reading or meditation, and had generally a nut to crack when we came together. Plato and Aristotle were never long out of his hands; he was also an assiduous reader of all works on science, especially if they involved the method of science; but the book that was now oftenest in his hands, in the intervals of work, was Mill's "Logic." I doubt if any living man conned and thumbed the book as he did. "John Mill's 'Logic,'" I remember his saying, "is the best book in my library." He had not the same high opinion of any of Mill's other books. He was himself one of nature's logicians; he was a thoroughgoing upholder of the Experience-philosophy, and Mill's "Logic" completely satisfied him on this head. Often and often did he recur to the arguments in favor of *a priori* truth, and he was usually full of fresh and ingenious turns of reply. It was only in Mill that he could find a talker to his mind in this region, as in philosophy generally. Equally intense was his devotion to utility as the basis of morals, and still more varied was his elucidation and defense of the principle; on that topic also he had few that he could declare his whole mind to, and this was another bond of attraction to Mill. Toward himself, on the other side, Mill had an almost filial affection, and generally gave him the earliest intimation of his own plans; but, much as he loved Grote's company, his movements were under the control of a still greater power. Notwithstanding their wide agreement, and numerous bonds of sympathy from this cause, as well as from long intimacy, Grote had always a certain misgiving as to his persistence in the true faith. He would say to me, "Much as I admire John Mill, my admiration is always mixed with fear," meaning that he never knew what unexpected turn Mill might take. This I regarded as an exaggeration due to Grote's gloomy temperament, as well as to the shock of the "Bentham" and "Coleridge" articles; and to Mill's consequent making himself at home with Maurice, Sterling, and Carlyle, with whom Grote never could have the smallest sympathy.

The first opinion held by both that I found occasion to controvert, in those early conversations, was the Helvetius doctrine of the natural equality of human beings in regard of capacity. I believe I induced Grote at last to relax very considerably on the point; but Mill never accommodated his views, as I thought, to the facts. With all his wide knowledge of the human constitution and of human beings, this region of observation must have been to him an utter blank.

This summer (1845) produced the article on Guizot, the last of his series on the French historians (apart from Comte). It seems to have been a great success, even in the point of view of the old "Edinburgh Review" connection, to which it was often an effort to accommodate himself. Jeffrey ("Napier Correspondence," p. 492) is unusually elated with it: "a very remarkable paper," "passages worthy of Macaulay," "the traces of a vigorous and discursive intellect." He did not then know the author; when made aware of the fact, he adds, "Though I have long thought highly of his powers as a reasoner, I scarcely gave him credit for such large and sound views of *realities* and practical results." The reader will remember that the most prominent topic is the Feudal System.

We are now at the commencement of the "Political Economy," which dates from the autumn of this year. The failure of the "Ethology" as a portal to a complete sociology left the way clear for this other project, at a time when his energy was still up to great things. Indoctrinated as he was from babyhood in the subject, and having written on it in articles and discussed it, both in private and in the Political Economy Club, with all the experts of the time, it seemed to offer a fine field for his expository powers. Add to which, he found he could attach to it his views as to the great social questions; although, it must be allowed, the bond of connection was somewhat loose, and the larger sociology would have been a more fitting occasion for such wide-reaching topics.

In a letter dated February, 1846, he announces that the third part of the "Political Economy" is written. He says, in the "Autobiography," that it was the most rapidly written of any of his books; which showed that the subject had been well matured. He turned aside to write an article for the "Edinburgh" on French politics, the text being a series of political papers by Charles Duveyrier. Louis Philippe was now at the height of his prosperity; but the political system was very unsatisfactory: and Mill returned for a little to his old interest in France, and discussed in his usual style the workings of the constitutional system, its weakness and its remedies. His author —a calm, clear-sighted reasoner—put much stress upon a second Chamber made up of old officials, and Mill sympathizes with his object in desiring a counterpoise to democracy; but remarks, with his usual acuteness, "It is not the uncontrolled ascendancy of popular power, but of any power, which is formidable." The article came out in

April, 1846. It appears that the editor thought fit to omit a passage controverting the prevailing notion of the warlike propensity of the French. Mill wished the passage had been retained: "The opinion is a very old and firm one with me, founded on a good deal of personal observation." He adds, "The 'Edinburgh' has lately been sometimes very unjust to the French." He further interrupted the "Political Economy" to write his review of Grote's first two volumes, which appeared in the "Edinburgh" in October. This was, in every sense, a labor of love—love of the subject, love of the author, and admiration of the work. Writing in September, he says: "I have just corrected the proof of my review of Grote, in which I have introduced no little of the Comtean philosophy of religion. Altogether I like the thing, though I wrote it in exactly four days, and rewrote it in three more, but I had to read and think a good deal for it first." His reading, I remember, included the whole of the Iliad and Odyssey, for the sake of the Homeric discussion in which he perilously ventured to differ somewhat from Grote. There was no man whose opinion Grote was more sensitive to, but the objections raised did not alter his views. In deference to Mill, he made some slight changes in the next edition. One, I remember, was to leave out of the preface the words "feminine" and "masculine," as a figurative expression of the contrast of the artistic and scientific sides of the Greek mind. Mill could never endure the differences of character between men and women to be treated as a matter of course.

In the letter above quoted, he announces that he has "got on well with the 'Pol. Ec.' I am on the point of finishing the third book (Exchange)." He was now beginning his hardest winter, after 1842–'43. It was the winter of the Irish famine, and he thought he saw an opportunity for a grand regenerating operation in Ireland. He began in the "Morning Chronicle" a series of leading articles, urging the reclamation of the waste land to be converted into peasant properties, and iterated all the facts showing the potency of the proprietary feeling in strengthening the disposition to industry. In the months of October, November, December, and January, he wrote two or three leaders a week on this topic; we used to call these, in the language of the medical schools, his "Clinical Lectures." He was pushing on the "Political Economy" at the same time. Moreover, a letter to his brother James (2d November) shows that he was laboring under illness—"had been ill, now better, but still a bad cold." In the middle of November he wrote that the articles "have excited a good deal of notice, and have quite snatched the initiative out of the 'Times.' He adds: "It is a capital thing to have the power of writing leaders in the 'Chronicle' whenever I like, which I can always do. The paper has tried for years to get me to write to it, but it has not suited me to do it before, except once in six months or so." On the 28th of December, he says: "I continue to carry on the 'Pol. Econ.' as well as I can with the arti-

cles in the 'Chronicle.' These last I may a little slacken now, having in a great measure, as far as may be judged by appearances, carried my point, viz., to have the waste lands reclaimed and parceled out in small properties among the best part of the peasantry." In another month he changes his tune. On the 27th January (1847) he writes: "You will have seen by this time how far the Ministry are from having adopted any of my conclusions about Ireland, though Lord J. Russell subscribes openly to almost all the premises. I have little hope left. The tendency of their measures seems to me such that they can only bring about good to Ireland by excess of evil. I have so indoctrinated the 'Chronicle' writers with my ideas on Ireland that they are now going on very well and spiritedly without me, which enables me to work much at the 'Political Economy,' to my own satisfaction. The last thing I did for the 'Chronicle' was a thorough refutation, in three long articles, of Crocker's article on the Division of Property in France." Two months later, he announced that the first draft of the "Political Economy" was finished. As to public affairs: "The people are all mad, and nothing will bring them to their senses but the terrible consequences they are certain to bring on themselves, as shown in Whately's speech yesterday in the House of Lords—the only sensible speech yet made in either House on the question. Fontenelle said that mankind must pass through all forms of error before arriving at truth. The form of error we are now possessed by is that of making *all* take care of *each*, instead of stimulating and helping each to take care of himself; and now this is going to be put to a terrible trial, which will bring it to a crisis and a termination sooner than could otherwise have been hoped for."

Before passing from this memorable winter, I may mention that Liebig, in a reprint of his "Animal Chemistry," handsomely repaid the notice taken of his researches in the "Logic," saying of his amended views that "he feels that he can claim no other merit than that of having applied to some special cases, and carried out further than had previously been done those principles of research in natural science which have been laid down" in Mill's book. Mill exultingly remarked: "The tree may be known by its fruits. Schelling and Hegel have done nothing of the kind."

Before arriving in London this year, I had another letter (5th of May). He delays to commence rewriting till he sees the upshot of the Irish business. "The conduct of the Ministers is wretched beyond measure upon all subjects; nothing but the meanest truckling at a time when a man with a decided opinion could carry almost anything triumphantly." I saw him as usual during the summer, but do not remember any incidents of importance. Grote was in town for several weeks on the publication of his third and fourth volumes, which was a new excitement. I went down to Scotland in the autumn, but having no longer any teaching-appointment there, I returned to London in

November, and entered the Government service, and was therefore in constant residence until I saw fit to resign in 1850. For this interval, I have not the advantage of possessing any letters from Mill, and can only give a few scattered recollections of the more impressive occurrences.

The "Political Economy" was published in the beginning of 1848. I am not about to criticise the work, as I mean to do the subsequent writings, but I have a few remarks to make upon it. One modification in the laying out of the subject he owes, as I have already said, to Comte's sociological distinction into Statics and Dynamics. This is shown in the commencement of the fifth book, entitled "The Influence of the Progress of Society in Production and Distribution." I can believe, although I am not a political economist, that this distinction may have been as useful in political economy as in politics. He spoke of it to me at the time as a great improvement.

But what I remember most vividly of his talk pending the publication of the work, was his expectation of a tremendous outcry about his doctrines on property. He frequently spoke of his proposals as to inheritance and bequest, which, if carried out, would pull down all large fortunes in two generations. To his surprise, however, this part of the book made no sensation at all. I can not now undertake to assign the reason. Probably people thought it the dream of a future too distant to affect the living; or else that the views were too wild and revolutionary to be entertained. One thing strikes me in the chapter on property. In section 3, he appears to intimate that the children even of the wealthy should be thrown upon their own exertions for the difference between a bare individual maintenance and what would be requisite to support a family; while in the next section he contemplates "a great multiplication of families in *easy circumstances*, with the advantage of *leisure*, and all the real enjoyments which wealth can give, except those of vanity." The first case would be met by from two to five hundred pounds a year; the second supposes from one to two thousand. The whole speculation seems to me inadequately worked out. The question of the existence of large fortunes is necessarily a very complex one; and I should like that he had examined it fully, which I do not think he ever did.

His views of the elevation of the working-classes on Malthusian principles have been much more widely canvassed. But there is still a veil of ambiguity over his meaning. Malthus himself, and some of his followers, such as Thomas Chalmers, regarded late marriages as the proper means of restricting numbers; an extension to the lower classes of the same prudence that maintains the position of the upper and middle classes. Mill prescribes a further pitch of self-denial, the continence of married couples. At least, such is the more obvious interpretation to be put upon his language. It was the opinion of many, that while his estimate of pure sentimental affection was more than

enough, his estimate of the sexual passion fell a good deal below the truth.

The strong leanings toward some form of socialism, indicated in the "Autobiography," would have led us to believe that his opinions nearly coincided with those of the Socialists commonly so called. The recent publication of his first draft of a projected essay on the subject shows the wide gulf that still separated him and them. The obstacles to the realizing of socialistic schemes could not be more forcibly expressed. Above all, the great stress that he always put upon individuality would be almost impossible to reconcile with the constructions of Fourier, Owen, Louis Blanc, and the American communities. His socialism is thus to be the outcome of a remote future, when human beings shall have made a great stride in moral education, or, as Mr. Spencer would express it, have evolved a new and advanced phase of altruism.

The publication of the "Political Economy" was followed by another very serious break-down in his health. In the summer of 1848, an affection of the thigh (I am not sure whether it began in a hurt) was treated by his doctor with iodine; the consequence of which was a speedy impairment of his eyesight. I remember him in a state of despair from the double misery of lameness and blindness. His elasticity of constitution brought him through once more; but in the following year (1849) he was still in an invalid condition. I introduced to him that year Dr. Thomas Clark, of Marischal College, himself a permanent invalid from overwork, who spoke a good deal to him about regimen, and endeavored to induce him to try the water-treatment, then just started. He was, however, not to be moved from his accustomed routine. His view of the medical art (at the time I speak of) was, that it should restore a shattered frame by something like magic. In other respects, his intercourse with Clark gratified him much, and led to a permanent friendship.

His work, as a great originator, in my opinion, was now done. The two books now before the world were the great constructions that his accumulated stores had prepared him for; and I do not think that there lay in him the materials of a third at all approaching to these. It is very unlikely indeed that he was even physically capable of renewing the strain of the two winters—1842–'43 and 1846–'47. His subsequent years were marked by diminished labors on the whole; while the direction of these labors was toward application, exposition, and polemic rather than origination; and he was more and more absorbed in the outlook for social improvements. Not that his later writings are deficient in stamina or in value; as sources of public instruction and practical guidance in the greatest interests of society, they will long hold their place. But it was not within the compass of his energies to repeat the impression made by him in 1843 and again

in 1848. We must remember that all through his severest struggles, he had a public official duty, and spent six hours every day in the air of Leadenhall Street; and although he always affected to make light of this, or even to treat the office-work as a refreshing change from study, yet when his constitution was once broken, it would tell upon him more than his peculiar theories of health and work would let him confess.

In another article, I propose to review the writings subsequent to the date now reached.

OCEAN METEOROLOGY.

By Lieutenant T. A. LYONS, U. S. N.

WERE the captain of a ship to contemplate making a passage in a sea he had never before traversed, he would find it desirable to be supplied with charts of two different kinds: one kind showing the rocks, shoals, and other dangers scattered throughout its expanse, the contour of its islands and bounding shores, and the soundings of its shallow waters; the other kind giving full and reliable information regarding its winds and weather, storms and currents, barometric and thermometric fluctuations. The first is essential to safe navigation; the second an invaluable auxiliary to a speedy passage. It is of this second kind—meteorological charts—that this article is to treat.

And, first, partly to introduce the subject, partly to illustrate it, I will very briefly touch upon a similar work for the land—a work which has now become familiar to all—I mean the daily synopsis and forecast of the weather published by the United States and several European Governments for the benefit of their people.

The value of an extensive organization for observing atmospheric phenomena was early appreciated in Europe, and as long ago as the year 1780 the Society of the Palatinate was established under the auspices of the Elector Charles Theodore, who entered with spirit and ability into its pursuits, and furnished it with the means of defraying the expense of instruments of the best construction, which were gratuitously distributed to all parts of Europe, and even to America. Some idea may be formed of the comprehensive scale of the journal of this society, when it is known that it contains observations three times in the day of the barometer, thermometer in the shade and in the sun, hygrometer, magnetic needle, direction and force of the wind, quantity of rain and of evaporation, the height of any neighboring water, the changes of the moon, the appearance of the sky, and the occurrence of meteors and of the aurora borealis. To these must be added, in some places, observations upon the electrical state of the

atmosphere, upon the progress of vegetation, the prevalence of disease, changes of population, and migration of animals. The field of observation extended from the Ural Mountains in the east to Cambridge, in the United States, in the west; and from Greenland and Norway in the north to Rome in the south. This range included also stations upon three high mountains in Bavaria and upon the summit of St. Gothard. The observations of each year are summed up and compared with those which precede, in copious and most laborious tables of mean and extreme results, and many very interesting essays upon various branches of meteorology are interspersed throughout the volumes of the society.

Unfortunately for science, the secretary, Hemmer, died in the month of May, 1790, and from that time the society appears to have languished, and finally to have become extinct amid the troubles and the wars of the French Revolution.*

It might be of interest to trace the progress of meteorology since the days of the Palatinate Society—to recount the many improvements in the instruments, the new auxiliaries impressed into its service, the successive unfolding of its laws as immense masses of data came into view, and the gradual passing of the subject from the care of amateurs, who pursued it mostly as a pastime or matter of curious inquiry, into trained hands and organized bodies maintained by liberal government support. But this is not my purpose here: with a passing glance at an important guide-post erected about the year 1840 on the highway of this science, I will make a single stride over all this field and come at once to the problem proposed to the meteorologist of the present day, and the means at his command for its solution.

The writer of this guide to the way beyond gives in clear-cut outline all that has since been realized both in this country and England. After stating the necessity of making observations on land coördinate with those at sea, in order to study the atmosphere in its entirety, he uses these prophetic words: "This extension of the system landward was proposed in the beginning as a part of the original plan. I have never ceased to advocate it since, and to couple with it a system of daily weather reports through the telegraph. As much as we have accomplished at sea, more yet can be accomplished through the magnetic telegraph on the land. With a properly devised system of meteorological observations to be made at certain stations wherever the telegraph spreads its meshes, and to be reported daily by telegrams to a properly organized office, the shipping in the harbors of our seaport towns, the husbandman in the field, and the traveler on the road, may all be warned of every extensive storm that visits our shores, and while yet it is a great way off. The laurels to be anticipated from such extension of our beautiful field of research would crown the results

* For these particulars of the Society of the Palatinate I am indebted to the valuable treatise on meteorology by the late Professor John Frederick Daniell, of England.

already obtained, and probably entitle the whole to be regarded as among the most splendid achievements of the age. With this system established, and conducted as it ought to be, no ship need ever put to sea from any of our seaports in ignorance of the approaching storm. A like system for the British Islands and the Continent would lead to like results there; many storms, after visiting our shores, travel across the ocean and carry devastation there. Should the sub-Atlantic telegraph be laid, and, when laid, should it answer its ends, warnings of all such storms may be sent across the ocean several days in advance." —("Sailing Directions," by Lieutenant M. F. Maury, U. S. N., vol. i., p. viii. of Introduction.)

To recur to the problem of the meteorologist of to-day, it assumes three distinct phases: first, from a number of observations extending through many years and over a large expanse of land or sea, to discover the laws of atmospheric phenomena; second, from an unbroken series of observations at any one place, through a sufficiently long period to eliminate all merely adventitious changes, to determine the climate of that place; and third, from a number of simultaneous observations at different points of any circumscribed area, to predict what the weather will be over that area for any short time.

The solution of the first phase is all but complete: the great governing principles of our atmosphere are now quite well known—it is only the details that need defining. That of the second phase can scarcely be said to be more than begun: in only a few places on the globe have accurate observations been continued for a long enough period to reliably define their climates; but of late years, especially during the last twenty, such an interest has been awakened in this subject, that ere the century closes very many cities will possess the data for thoroughly describing the atmospheric changes to which they are subject, not according to the recollection of the oldest inhabitant, but by accurate records—figures that never deceive.

The effect of the weather upon mankind is only too well known: with the invalid or convalescent it is often a matter of life or death; with us all, how different our feelings on a fresh, genial day, when the air is dry and bracing, and a bright sun illumines an azure sky—how elastic, how full of vigor are we, compared with the lethargy that seizes us in somber, bleak weather, when dense, misty clouds hang in heavy folds around us, and shade even our very sensations with their gloom!

In Boston, the *east* wind of spring and autumn is a source of annoyance to its inhabitants; it comes laden with moisture and—coughs. In California, it is an equally unwelcome visitor, but for a very different reason: it parches and all but cracks the skin. In both places, the relative prevalence of this wind is a fact important to know. In Buffalo, the storms that sweep in from the lakes are disagreeable in the extreme; in Texas, the fierce blast of the norther is often very

destructive. But all these instances are peculiarities singled out from a variety of items, highly interesting to any one contemplating either a temporary or permanent residence in a place new to him. The storms, the rain, and the snow he has to encounter; the average humidity and tenuity of the air he has to breathe; the variety and character of the winds that are to blow upon him; the mean and extreme of the daily, monthly, and yearly temperature to which he will be subjected; the relative number of cloudy and clear days—all this, constituting the climate of a place, should be known to one ere he hazards his comfort, his good feeling, or, it may be, his health, by a change of residence. And it is probable that, with the great number of observers now carefully noting and recording these items in various cities, the day is not far distant when their laborious experience of long years will be classified, reduced, and published in such a compendious form, that a stranger to any given place may, by half an hour's study of this publication, inform himself correctly as to its climate.

The solution of the third phase of the problem is the one productive of most immediate benefit to all, how much soever their callings may differ; and this universal interest warrants my stating its conditions more at length than I have done with the other two. This phase may be likened unto an algebraic equation—a combination of known and unknown quantities, which, being operated upon according to certain rules, gives a desired result.

First, to determine the known quantities, a variety of instruments must be read and recorded at stated periods. These are, anemometers, to indicate the direction and velocity of the wind; barometers, to measure the pressure of the air; and hygrometers, its humidity. Suppose sets of these, standard in quality, to be furnished a corps of trained observers stationed at various points throughout a given area, say a thousand square miles; let each observer note his instruments at predetermined hours, or, better, let the observation be automatic and continuous, which is now often done by means of mechanical contrivances; let a network of telegraphy connect all the stations with some central point: then, at any moment he wishes, a person at this point can ascertain the prevailing weather all over the area, or, in other words, the known quantities of his equation. Now, the atmosphere that encircles our globe is but an ocean of less density than the watery element that surges upon its surface; like that, it moves, contracts, and expands according to well-known physical laws, and these laws constitute the rules whereby the person at the central station operates on his known quantities, solves the equation, and obtains for a result the forecast of the weather for the next few hours.

Having a due regard for the conformation of the ground over which his prognostics extend, he well knows that, according to the relative variation of pressure, temperature, and moisture, there will be a corresponding variability of weather: that if the pressure is great

at one place and slight at another, the air will as naturally flow from the former toward the latter as water will down an inclined plane; and as the velocity of the water will depend on the inclination of the plane, so will the violence of the wind be chiefly due to the difference of pressure: hence the direction and force of the wind are predicted. Again, whether the day will be warm or cold depends mostly on the temperature of this wind; and, furthermore, if it contains much vapor and blows toward a point where the temperature is lower than that from which it started, clouds, or rain, or snow will follow, according to the difference of temperature and the supply of vapor; but if a saturated wind blows toward a place where the temperature is high, and air dry, its moisture will be licked up by the thirsty air, and a mere haze will ensue, or clear weather continue.

This problem in its ever-varying conditions is the one daily solved by the Weather Bureaus of several Governments, in the interest of agriculture, comfort, and commerce; and perhaps nowhere more successfully than by our own. With its large corps of trained observers, its military discipline, variety of standard instruments, extensive field of operations covered by telegraphic lines, liberal Government support, and educated intelligence to guide the whole, there is every reason for the confidence so generally felt in the weather prognostics of the Signal Office of the United States Army.

With this preliminary glance at meteorology on the land, I shall now pass to a consideration of it as regards the ocean—the subject proper of this article; and as I have already divided the problem into three phases, it will be convenient to maintain this distinction—only, that for the ocean, the cases reduce to two: first, to seek out the hidden cause of the winds, whether as the gentle trades that scarcely ruffle the waters over which they glide, or as the violent hurricane that lashes the waves into a tempest of confusion; and, secondly, to determine the many items that, together, make up the climate of small areas of every sea.

The third phase of the problem on land is entirely excluded from the ocean. There we can not establish fixed stations and spread a web of electric wire over them, with some guiding genius ensconced in the midst. We can not (as is done every morning in the United States, England, France, and Germany, for the limits of each country) say what the weather will be, and how the winds will blow, for the ensuing twenty-four hours, in the Indian Ocean, the South Seas, or the North Atlantic. But we *can* give information yielding in no degree in importance to this purely ephemeral benefit; and the manner in which this is obtained and published is what I shall fully describe hereafter.

To the late Commander M. F. Maury, of the United States Navy, is due the credit of having given to ocean meteorology that vigorous impulse that placed it in the foremost rank of pursuits, and justly

obtained for its advocate his distinction in this branch of physical science. He planted a germ which, under his own assiduous care, grew and overspread the globe: its seed fell in every maritime nation, and to-day they are producing meteorological charts of the ocean—all modifications or elaborations of his useful idea. It is therefore but proper that I should here give a short sketch of both himself and his great work.

MATTHEW FONTAINE MAURY was born in Virginia, January 4, 1806. He entered the navy as midshipman in 1825, and was promoted to the grade of lieutenant in 1836, having in the interval been attached to various cruising-vessels, on which he performed the customary duties of a sea officer. It was during one of these cruises that the outline of his future work acquired form and shape in his brain.

In 1839 an accident permanently incapacitated him for further service at sea, and he was therefore given charge of the depot of charts and instruments in Washington: this was soon afterward united to the Naval Observatory, and he became superintendent of both, retaining the position uninterruptedly until 1861—a period of more than twenty years. Later still, the scope, character, and importance of the chart department grew to such dimensions as to necessitate its separation from the observatory: this was done, and it became the Hydrographic Office, which it continues to this day, under the management of a naval officer. At present, it has no closer intimacy with the observatory than being under the guidance of officers of the same branch of the Government—the navy.

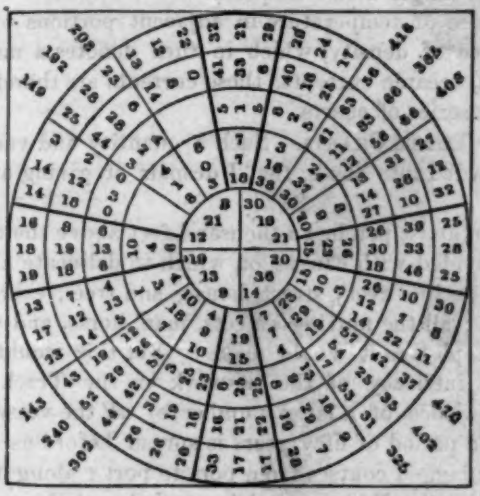
Maury was promoted to the grade of commander in 1855, and it was then also that he attained the height of his scientific fame: he had written his "Physical Geography of the Sea"; he had been chiefly instrumental in bringing about the Brussels Conference, whereby the civilized nations of the world entered into his plan of "ocean meteorology"; he had prepared his ponderous volumes of "Sailing Directions"; he had received the encomiums of numerous scientific bodies both native and foreign; and, with the constant aid of a large number of naval officers, he had compiled, with incredible labor and pains, that series of charts that has made his name so familiar to sailors, whatever the flag they sail under.

On the 1st of February, 1873, after having done more than any other man that preceded him toward tracing the wind in its circuits, and showing the navigator how to take advantage thereof, he died at Lexington, Virginia, in the sixty-eighth year of his age.

I will now give an outline of the charts compiled under Maury's direction. A full description would necessitate the reproduction of specimen-sheets, and that is impracticable here.

First and most important are the PILOT CHARTS. These give for small areas of ocean—every five degrees square—the relative frequency of different winds during each month. The following figure is a

sample square of the whole series, and a few explanatory words will disentangle this web of figures. The radii extending from the inner to the outer circle inclose sixteen points of the compass—as north, north-northeast, northeast, etc. Every two concentric circles contain the data for each season. The problem being, then, to compare the relative prevalence of the *same* wind in different months, it is done as follows: suppose it a northerly wind; looking at the figures between



the two radii opening toward the top and between the outer and second circles, we see that, of periods of eight hours each, there were 32 in December, 21 in January, and 29 in February; the figures between the same radii and the second and third circles show that there were 41 periods in March, 33 in April, and 6 in May; and similarly, for each wind between every two radii. To compare *different* winds for the same month, say December, we look at the first figure to the left in each space between the outer and second circles, and find that, of periods of eight hours each, the wind was 32 times from the north, 29 times from north-northeast, 56 from northeast, and so on round the compass.

The figures 416, 385, and 408, in the upper right-hand corner, denote the total number of observations in December, January, and February, respectively; and similarly for the other months in the other corners. The figures in the center express the periods of calm in the several months.

Though this arrangement is compact and ingenious, still, when we come to make the comparison that is the real object of the chart, viz., the relative frequency of different winds in several adjoining squares, we find the task a little irksome.

Second, the THERMAL CHARTS. These show the temperature of the

sea-water at the surface for every month, isothermal lines bring drawn at every 10° from 40° to 80° Fahr. By using three colors, and a different arrangement of the figures for each season, all the observations of each month are made separately visible on one sheet in the spot where taken. The sheet thus appears to the eye a continued intermingling of curves and figures—blue, red, and black—generally open and easily traced where the observations are moderate in number, but an inextricable tangle where frequent.

As difference of temperature in adjacent portions of the sea indicates difference of density, which in turn denotes a mobility of the waters, that is, oceanic currents, these currents are therefore indirectly shown by this series of charts.

Third, the TRACK CHARTS. Such a quantity and variety of information is crowded into these, that I despair of giving any intelligible idea of them.

Imagine an artist perched a thousand feet above the center of New York and provided with canvas on which to delineate the city below —to trace in outline every street, house, and tree; every railway and telegraph line; all the moving objects, man, horse, and vehicle—what a complicated picture it would make! Yet this would by no means represent the intricacy of the network on the Track Charts. On them the experience of a large number of *all* the vessels that sailed the ocean for a period of fifty years is spread before us. Most prominent are their jagged courses from port to port; along these are symbols to represent the direction and force of the wind: roman numerals to express the magnetic variation; arrows and figures to indicate the set and strength of currents; figures to show the temperature of the sea-water; great circle routes; trade-wind limits; the name of each ship and date of making the passage—and all this in distinctive colors and peculiarity of line, so that each item can be determined with great exactness as regards both time and space.

Indeed, this profuse interweaving and crossing of lines and figures taxes the patience of even the most painstaking mariner. What the charts show forcibly at a glance, are the great ocean highways, but this chiefly by the multiplicity of tracks through the beaten paths, compared with their sparseness over less frequented routes.

Fourth, the STORM AND RAIN CHARTS. For every five degrees square and each month, they clearly show the relative prevalence (compared with the whole period of observation) of the following phenomena: gales from eight cardinal points of the compass, calms, fogs, thunder and lightning, and rain (including hail, snow, and sleet).

The arrangement of these charts is excellent, and they are easily understood.

Fifth and last of the entire set, the TRADE-WIND CHARTS OF THE ATLANTIC OCEAN. By a judicious use of colors, figures, and lines, the limits of both trades, of the calm belt between, and of the calm zone

on the outer border of each system of trades, together with the several observations by which these limits were determined, are all clearly and distinctly shown for each month, on a single sheet.

In 1863 the publication of Maury's charts was discontinued; but in 1876 other charts, similar in nature, though entirely different in the method of compilation, were begun, are now in progress, and will be continued, until sets for all the navigable waters of the globe are completed; and it is a description of these new charts that will constitute the second paper of this article.

THE STUDY OF PHYSIOLOGY.

By P. H. PYE-SMITH, B. A., M. D.,
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BIOLOGY is the science of the structure, the functions, the distribution, and the succession in time of all living beings. If the proper study of mankind be man, he has learned late in the inquiry that he can only understand himself by recognizing that he is but one in the vast network of organic creation; that intelligible human anatomy must be based upon comparative anatomy; that human physiology can only be approached as a branch of general physiology, and that even the humblest mold or sea-weed may furnish help to explain the most important problems of human existence.

The branch of physiology which is concerned with man, not as an individual, but a family, the branch which we now call Anthropology, is obviously related to practical politics, and it was not without reason that the late illustrious pathologist Rokitansky began a speech in the Upper House of the Austrian Parliament on the autonomy of the Bohemian nation with the words, "The question really is, whether the doctrine of Darwin be true or no."

In another department, that of psychology, the physiology of the nervous system has already thrown more light upon the mysterious phenomena of consciousness than was gained by the acutest minds of all ages without the help of anatomical methods.

All the improvements of modern agriculture and stock-breeding rest upon more or less fully understood scientific principles, and the more perfectly the results have been first worked out in the laboratory the more safe and the more lucrative will be their application in the field.*

Still more important is the relation of physiology to the national health. The commonplaces of hygiene which are now, one may be

* I need only refer to the fruitful labors of Mr. Lawes and Dr. Gilbert in this direction.

thankful to say, taught, if not practiced, in almost every schoolroom and factory in England, are the direct results of the abstruse researches of Boyle and Priestley, of Lavoisier and Pasteur. Ages of experience did not teach mankind the value of fresh air, or the innocence of clean water. Indeed, I have myself heard astonishment expressed by a German professor at the peculiar immunity with which English skins will bear the daily and unstinted application of soap and water.

If the art of keeping a community in health is but the application of plain physiological laws, it is no less true that the art of restoring the health, curative as distinct from preventive medicine, rests upon the same basis. In former days the physician was one who recognized what he called the disease of his patient, who referred to his books of precedents as a lawyer to his statutes, and who prescribed a proper remedy to cast out the disease. We now know that disease is, as the name implies, a purely subjective conception. The disease of a host is the health of the parasite, and we cure a human sufferer by poisoning the animals or plants which interfere with his comfort. The same changes which in the old man are the natural steps of decay, the absence of which after a certain age would be truly pathological, are the cause of acute disease in the young. Pathology has no laws distinct from those of physiology.

When these now obvious considerations are thoroughly understood, it clearly follows that all "systems of medicine" are in their very nature condemned. All that the art of medicine can do is to apply a knowledge of natural laws, of mechanics and of hydrostatics, of botany and zoölogy, of chemistry and electricity, of the behavior of living cells and organs when subjected to the influence of heat and of cold, of acids and alkalies, of alcohols and ethers, of narcotics and stimulants, so as to modify certain deviations from ordinary structure and function which are productive of pain, or discomfort, or death. It is, therefore, plain that rational medicine, or keeping right and setting right the human body, must rest upon a knowledge of its structure and its actions, just as a steam-engine or a watch can not be mended upon general principles, but only by one who is familiar with their construction and working, and who can detect the source of their irregularity.

An objector may say: "Admitting that medicine is an art, it is a purely empirical art. You can not detect the origin of many of the maladies which you are yet able to cure; your best remedies have not been obtained by scientific experiment, but by chance, observation, and accumulated experience; and, if you doctors would give more time to practical therapeutics, that is, to finding out what is good for the several aches and pains we complain of, you would spend your time better than in abstruse researches into microscopic anatomy or the properties of a dead frog's muscle."

The answer to the objection is an appeal to fact. For centuries so-called observation and experience left medicine in the condition it

occupied at the end of the seventeenth century. The progress of therapeutics is to be marked, not by the labors of "practical men" (who, by the way, are of all the most theoretical, only that their theories are wrong), but by the, at first sight, unconnected studies of Descartes and Newton, of Hooke and Grew, of Lavoisier and Davy and Volta, of Marshall Hall and Johannes Müller.

The history of science proves that unconnected, unsystematic, inaccurate observations are worth nothing. For untold ages men have had ample opportunities of studying the indications of the weather, and have felt the utmost desire to obtain a knowledge of what they portend. Yet it may fairly be said that nothing had been done to the purpose until combined and systematic observations were made in this country and America. The fact is, that popular notions do not rest upon experience or observation. They rest, with scarcely an exception, upon metaphysical theories. In dealing with uneducated persons, both of the lower and higher ranks, physicians find abundance of theories as to the nature and the origin of disease, and of suggestions as to its cure. The only thing which would be of value is what we can scarcely ever get—an accurate observation of what they see and feel. Every fallacy of popular medicine, every solemn medical imposture, is the ghost of some long defunct doctrine of the schools. Therefore it is that common experience is almost absolutely useless in practical arts. They, without exception, depend for their progress upon the advance of science—that is, upon methodical, continuous, and scrupulously accurate observations and experiments.

Many important advances in the practice of medicine have been gained by direct and intentional experiments instituted with a therapeutical object. Such was the Hunterian operation for aneurism, the process of skin-grafting, and subperiosteal operations; such was the administration of chloroform and the introduction of nitrite of amyl, chloral hydrate, and carbolic acid. Such direct experiments still go on, and among them deserve mention, for the skill and the untiring patience with which they were carried out, those investigations upon the action of various drugs on the secretion of bile for which we are indebted to Professor Rutherford and his coadjutors. Even apparently accidental discoveries were not made accidentally. Hundreds of country surgeons must have been familiar with the cow-pox, and have seen examples of the immunity it conferred from the more terrible variola, but he who discovered vaccination was no falsely-called practical man. He was a man of science, the friend of Hunter and of Cavendish, an anatomist and natural philosopher. The fruits of Jenner's discovery are spread over the whole earth. This humble village doctor has saved more lives than the most glorious conqueror destroyed, but his name is little honored, and the only monument to his memory has been banished from association with vulgar kings and skillful homicides to an obscure corner of the great city where his

only homage is the health and beauty of the children who play around his statue.

But, after all, it is not so much by direct and immediate contributions to the art of healing that Physiology has vindicated her ancient title of the institutes of medicine, numerous and important as these contributions have been. It is still more by the scientific spirit which has transformed the empty learning so justly ridiculed by Molière and Le Sage into the practical efficiency of modern surgery. Let me give an instance of what I mean. The notion of measuring the temperature of the body is simple enough, and the rough observation that in inflammation the temperature is raised had led to the various terms by which it was denoted in ancient medicine, and to numberless theories now happily forgotten. But although the thermometer was well known, and had been applied by many scientific physicians, notably by De Haen, by Dr. John Davy, and by Sir Benjamin Brodie, yet the practical value of the clinical thermometer which now every practitioner carries in his pocket was not understood until the other day. Those only who had been trained in accurate physical and physiological investigations, who had learned the worse than uselessness of "rough observation," were able to see the enormous importance of clinical thermometry. This most practical of modern improvements in medicine would never have been dreamed of by "practical men"; we owe it to the scientific training of German laboratories.

If physiology is of such great national importance, if the necessity of experimental research is so vital to the common national wealth, to agriculture and commerce, to health and well-being, ought not its well-ascertained results to be taught in our common schools, and its prosecution directly encouraged by the state?

There is no question of the great importance of children being taught the rudimentary laws of health, the bodily evils of dirt and sloth and vice, the excellence of temperance, the danger of the first inroads of disease. Such teaching, now broadcast in many excellent manuals, as "The Personal Care of Health," by the late Dr. Parkes, and Dr. Bridges's "Catechism of Health," is no doubt extremely valuable, and happily is daily more and more diffused. But when beyond the direct utility of such knowledge we attempt to make it an intellectual discipline, there are, I conceive, difficulties which will always prevent even elementary physiology from forming an important part of general education. First, there is the practical difficulty of the necessary dissections; next, the impossibility of making physiology demonstrative; and, thirdly, the abstruseness of the subject. It is impossible to have even an elementary knowledge of the laws of living beings without a very considerable familiarity with those of physics and of chemistry, and even in medical schools it requires all our efforts to prevent it degenerating into a mere dogmatic statement of

results, or a labored repetition of hearsay statements. As an intellectual discipline, for facility of demonstration, for the simplicity of the objects, their beauty and interest, their associations with the green lanes and broad moors of England, with the poetry of "Cymbeline" and "Lycidas," with fairy tales and local folk-lore—botany is to my mind the branch of natural science which is above all others to be chosen where one only can be taught. Next in importance I would place elementary physics, the knowledge of the simplest laws of masses at rest and in motion, of heat and light. Its great recommendations are its precision, its constant and useful illustrations in daily life, the interest it gives to the handicrafts and manufactures in which so large a number of English boys and girls are busied, and the necessity of such knowledge as the first step in acquiring all other natural sciences.

First, then, I would that every Sheffield girl should love flowers with the deep and abiding affection of familiar knowledge, and that every Sheffield lad should know every common plant in your beautiful woods, and find his purest pleasure on the heights of Bell Hagg and the broad expanse of Stanage Moor. And next I would that your workmen and work-boys should know so much of mechanics that they may take an intelligent pride in your vast factories, and that in some of them may be awakened the genius to which we trust to repeat in future generations the national services of Arkwright, and Watt, and Stevenson.

With regard to the endowment of research in biology, I must confess that I should be sorry to see it undertaken by government funds. That such investigations are of public interest, that they are difficult and expensive, and that at present they languish for want of adequate support, is all true. But this country is not so poor, nor our countrymen so wanting in public spirit, that we need appeal to the national purse to supply every ascertained want. Great as is the national importance of science, the nation is more important still; and even if that were the alternative, I would rather that we should indefinitely continue dependent on Germany for our knowledge than give up the local energy, the unofficial zeal which has made England what she is. Far better for the strength and the civilization of the nation that a thousand pounds were raised every year for the endowment of unremunerative researches in this wealthy town of Sheffield than that ten thousand were paid you by a paternal monarch or an enlightened department.

But surely there is no need for us to go to Parliament for such sums as we require. In the first place, scientific men themselves show a good example of not asking before they give. There is the modest sum which we raise in this Association, there are the funds for helping research of the Royal Society, the Chemical Society, the British Medical Association, the Iron and Steel Institute, the Whitworth

Scholarships. Next we have the resources of our universities, which have scarcely begun to apply themselves to the task. I need do no more than allude to the Cavendish Laboratory, or to the Physiological School at Cambridge, where a simple college tutor of rare ability, and of still more rare sympathy and energy, has in ten years achieved results which we need not shrink from comparing with those of the great Continental laboratories. The magnificent Museum of Anatomy, maintained by the College of Surgeons almost entirely out of their own funds, is another instance of private care for science to which we find no parallel abroad; and the Zoölogical Society wisely spends a large part of its income in prosecuting comparative anatomy, and in publishing its beautifully illustrated memoirs.

But besides the efforts of scientific bodies and the wealth of our national universities, we may surely look to the public spirit of ancient companies and corporations to do something for the cause of science. In the middle ages our country was covered with parish churches by private munificence; in the sixteenth century most of our public and grammar schools were endowed; in later times our great religious and charitable societies were founded. May we not hope that, before the close of the present century, the discriminating knowledge which alone prevents gifts of money from being a curse instead of a blessing to a community, may lead to the establishment of libraries, and museums, and laboratories by universities and towns, which shall bear comparison, I will not say with those of Paris, or Leipsic, or Bonn, but with the poorer but scarcely less distinguished schools of Heidelberg and Göttingen, of Würzburg and of Utrecht?

Where we have institutions already under government control and patronage, let them be maintained as efficiently and liberally as possible. The British Museum, and its library, the Royal Observatory at Greenwich, and the Royal Gardens at Kew (happily preserved for the present from the short-sighted eagerness of those who would destroy their scientific value)—these are great national institutions of which we are justly proud. Successive governments will have enough to do to maintain their efficiency and to guard them from incompetent interference.

Whatever may be thought of the duty of the state directly to encourage the pursuit of animal and vegetable physiology, one would have supposed that at least what diplomatists call a benevolent neutrality would be shown to a pursuit so laborious and costly, which demands trained workmen and the devotion of a lifetime, which is so important for the national wealth and health, and which, by reason, by experience, and by testimony, we know to be the only guarantee for advance in the various branches of the healing art. Why is it then that institutions which owe nothing to government assistance, and men who spend their time and talents in self-denying and unre-

munerative service for the public good, are not suffered to pursue their beneficent work in peace?

You know that certain persons who profess to be shocked by the methods of physiological research have succeeded in placing this branch of science under as great disabilities as that sense of humor would allow which so often redeems British ignorance from its most mischievous results.

The method that has given rise to so much excitement is the performance of experiments upon living animals. Now, if this were injurious to the greatest good of the greatest number of the community, or if freedom to perform these experiments interfered with the freedom of other persons to abstain from them, or if such experiments were forbidden by any religious or moral authority, by the ten commandments, or by Mr. Matthew Arnold, of course they must be given up; but, equally of course, the science of physiology must also come to a stop, and the farmer, the cattle-breeder, and the physician must be content with such knowledge or such ignorance as he at present possesses. I know it has been asserted that the science of the functions of living organs is quite independent of experiment upon living organs. But this is said by the same persons who have denied that the art of setting right the functions of the body when they go wrong has anything to do with the knowledge of what those functions are.

If you could be persuaded that chemistry can make progress without retorts and balances, that a geologist's hammer is a useless incumbrance, or that engineers can build bridges just as well by the rule of thumb as by the knowledge gained in a workshop, then you might believe that physiology also is independent of experiment.

It is absurd to object to the difficulties of the research or even the contradictory results sometimes obtained. The functions of a muscle or a gland are more complicated than those of water or gas, and their investigation needs greater skill, more caution, and more frequent repetition. Imperfect experiments can lead to nothing but error; criticism from other physiologists, or from scientific men experienced in other branches of research, is not wanting, and is always welcome. But vague assertion that further progress is impossible by the very means which have led to all our present knowledge, coming from those "who are not of our school," or any school, is undeserving of serious notice.

The real contention, of course, is a moral one, that we ought to relinquish the advantage of all experiments which are accompanied with pain to the creature experimented on. The botanist may serve his plants as he pleases, and even the animal physiologist may cut, or starve, or poison all sentient organisms which happen not to possess a backbone, and he may try experiments with all backboned animals, including himself and his friends, so long as they do not hurt; but that must be the limit. On the most extreme humanitarian views no ob-

jection can be made to experiments upon animals in a state of insensibility to pain, and as these constitute, happily, the vast majority of physiological experiments, the question is narrowed to comparatively restricted limits. Is it wrong to inflict painful experiments upon animals for the sake of science? In the absence of any authority to appeal to, we can but judge of the matter by analogy. Now, it has been the practice of all mankind, and is still allowed by the common consent both of law and feeling, that we should destroy by more or less painful means, that we should enslave and force to work, and mutilate by painful operations, and hunt to death, and wound, and lacerate, and torture the brute creation for the following objects: for our own self-preservation, as when we offer a reward for the killing of tigers and snakes in India; for our comfort, as when we poison or otherwise destroy internal parasites, and vermin, and rats, and rabbits. Our safety, our food, our convenience, our wealth, or our amusement—all these objects have been and are regarded by the great mass of mankind, and are held by the laws of every civilized country, to be sufficiently important to justify the infliction of pain or death upon animals in whatever numbers may be necessary. The only restriction which Christian morality or in certain cases recent legislation imposes upon such practices is, that no more pain shall be inflicted than is necessary for the object in view. Killing or hurting domestic animals when moved by passion or by the horrible delight which some depraved natures feel in the act of inflicting pain was until lately the only recognized transgression against the law of England. I trust I need not say that it is only under such restrictions that physiologists desire to work.* Any one who would inflict a single pang beyond what is necessary for a scientific object, or would by carelessness fail to take due care of the animals he has to deal with, would be justly amenable to public reprobation. And remember it is within these limits that the whole controversy lies, for, after a long and patient examination of all that could be said by our accusers, the Royal Commission which was nominated for the purpose unanimously reported that in this country at least scientific experiments upon animals are free from abuse.

What is deliberately asserted is, that within the restrictions which all humane persons impose upon themselves, it is lawful to inflict pain or death upon animals for profit or for sport, for money or for pastime; that property and sport are in England sacred things; but that the practices which they justify are unjustifiable when pursued with the object of increasing human knowledge or of relieving human suffering.

Of those persons who answer that they consider vivisection for the sake of sport to be almost as detestable as vivisection for the sake of duty, I would only ask first that they should deal impartially with

* They are, in fact, the very limits that were put on record by this Association long before the agitation against physiology began. (See Report for 1871, p. 144.)

both offenses, and secondly that since in the one case their opinions are opposed to the practice of genteel society, and in the other to the convictions of all who are qualified to judge, they should at least contemplate the possibility of being mistaken. Putting the question of field sports altogether aside, you know perfectly well that in every village in England an extremely painful mutilation is constantly performed upon domestic animals in no registered laboratory, under no anæsthetics, and with no object but the convenience and profit of the owner. You remember how, when an epidemic threatened the destruction of valuable property, every booby peer now eager to stop, so far as in him lay, the advance of knowledge, was no less eager to have carried out at the public expense any slaughter and any experiments, painful or otherwise, which would save his pocket.

But you will say: All this seems reasonable enough; but if so, how do you account for the prejudice against you; what has induced so many amiable and otherwise sane persons to join in the outcry against physiology?

First, I answer, it is due to the most frequent cause of folly—ignorance. Many persons, supposed to be educated, are so destitute of the most ordinary conceptions of natural science that they do not understand the necessity for experiments. So little do they appreciate the difference between formal knowledge and real knowledge, that a distinguished statesman once assured me that he would as soon have his leg set by a man who had gained what he called his knowledge from books, as by one who had "walked the hospitals." Next, there is the vulgar dislike of whatever is not obviously and immediately useful. When knowledge for its own sake is in question, those of the baser sort are always ready to cry, with equal ignorance of literature and of science, "*Cui bono?*"

In another class of persons, less ignorant and less stupid than these two, opposition to physiological experiments appears to spring from what may fairly be stigmatized as sentiment, that is to say, excitable, rather than deep feeling, uncontrolled by reason. People first gratify their fancy by calling cats and dogs our fellow creatures, which, in one sense, undoubtedly they are, and then, by the familiar fallacy of an ambiguous middle term, argue that it is cruel to put our fellow creatures to pain; or, as some would add, to reduce them to slavery, or to use them in any way for our own, rather than their good. Such persons compel their fellow creatures to drag them through the streets, they eat their fellow creatures when sufficiently vivisected to be palatable, and then find philosophical excuses for those who kill their fellow creatures for fun. But they are properly shocked when their fellow creatures are hurt or killed for the benefit of mankind. Such persons have been accused of feminine weakness; but I must say that I never have found an intelligent woman who could not see the rights of the case when fairly explained to her, whereas I have met a few

men who in this, as in other matters, consistently refuse to give up to argument the notions which were formed by prejudice.

This sentiment is, I admit, the degradation of just feeling. To many unaffectedly compassionate hearts there is a peculiar pang in thinking of suffering which is deliberately inflicted, with only the justification of duty, instead of the excuse of ignorance or passion. They see in the helplessness of the dumb animals an appeal for pity, almost like that of childhood, and are justly indignant with the selfish cruelty so often exercised upon them. All honor to the efforts which have banished so many cruel sports from England; all honor to the society which seeks to prevent cruelty to animals! If it can point to any additional means by which the sufferings of animals in the cause of science can be diminished, we shall be anxious to adopt them. If it can point to any abuse in one of our laboratories, we will hasten to correct it. This society has honorably declared that they know of none. That physiologists have been heedless, or even callous, in their experiments upon animals in past times, when men were strangely insensible even to human suffering, or in countries where a healthy result of Christian civilization has not yet been seen in habitual gentleness to animals, I need not deny. Such cases have been eagerly sought and sometimes most unfairly judged. Only lately a learned body felt itself not strong enough to retain the admittedly invaluable services of an eminent foreigner, who had once admitted that when absorbed in scientific and beneficent researches he lost sight of any pain that might be inflicted.* Is not this the very excuse which is held valid in the case of sport? Doubtless we ought to be ever mindful of every branch of duty, but such occasional forgetfulness does not show hardness of heart. It is an excusable weakness for a student of medicine to shudder or to faint at the sight of blood, but he learns that this merely physical sensibility becomes selfish and mischievous if indulged: he is taught to suppress all such exhibition of emotion, and to let it stimulate without paralyzing his efforts to relieve. But no one surely would think the hysterical youth more truly humane than the surgeon whose compassion is shown in the very firmness with which he inflicts a temporary pain for an ultimate good.

I have hitherto rested the whole argument upon the lawfulness of inflicting pain and death upon the lower animals for the sake of science and humanity, but as a matter of fact I may again assure those who, while assenting to the justice of the plea, yet shrink from what it may involve, that the great majority of experiments upon animals are rendered painless, and that the remainder are mostly those experiments which are most immediately and directly subservient to medical art,

* Fortunately, Dr. Klein, whose researches in microscopic anatomy and pathology are so well known and appreciated, knows that he retains the confidence and respect of his scientific brethren, and we hope that his honorable connection with the largest school of medicine in London will strengthen other and closer ties in binding him to England.

and happily even these are generally productive rather of discomfort than of pain. Let me give you an example of such a vivisection, far more painful than the immense majority of those of the laboratory. Suppose a country surgeon were sent for late at night to some case of urgent peril; knowing that his ride is for life or death, and unsparing of himself or his horse, he rides him to the utmost limits of endurance, and beyond: who would not applaud the action? Those only who appear deliberately to believe that our life is worth less than that of many sparrows, those legislators only who look forward to the time when wars will cease, not because of human slaughter, of devastated homes, of all the horrors which the world has endured for centuries, but because of the cruelties to which the horses in the artillery are subjected. We, who are familiar with human suffering and sorrow, which our knowledge is all too feeble to prevent, best understand how, in testing some new remedy on a less precious fellow creature than a man, one who is truly humane may be tempted to forget the comparatively trivial suffering of a rabbit or a frog.

But some enthusiastic opponent will say: "I can not pretend to doubt that these experiments are in every sense of the word useful; but we ought not to purchase the benefit they confer by inflicting pain upon innocent creatures. I would sign a petition to-morrow to put down all field sports by law, I would allow no operation upon domestic animals, and I will abstain from all animal food until I am certain that I can eat creatures which have been killed without suffering pain. But if I were lying at the point of death, and you brought an animal to my bedside and assured me that by putting it to pain my life would be saved, I would refuse to purchase it on such cruel terms." We may hope that the excellent person who made this heroic profession would, in the hour of trial, be better advised, but if not we may surely reply: "Right reverend sir, you are the best judge of the value of your own life, and, if you think proper to sacrifice it to the comfort of a Guinea-pig, we must submit to the loss with such resignation as we can muster; but when you say that in obedience to this silly whim you will let your dearest friend suffer, allow the sacrifice of the most important life, and forbid those studies which have already rescued multitudes from deformity and misery and death, then those of us who have to do with the real responsibilities of life, and on whom presses the awful sense of impotence to which our defective science too often leaves us, answer that we too have duties to fulfill, and to the best of our power we mean conscientiously to fulfill them."

There is, I fear, another reason which animates much of the opposition to physiological experiments. It is nothing else than aversion from the methods and the results of science. It may be that an excuse for this dislike has been furnished by the pretense of false science, and the arrogance of much even which is true. But surely no reasonable creature, from such trivial irritation, can deliberately wish to

check the progress of accurate knowledge by observation and experiment. There are, indeed, some who, fearing (as I think prudently) that, "while a little philosophy inclineth men to atheism, depth in philosophy bringeth men's minds about to religion," and desiring to subject the human mind to a bondage as hard and more degrading than that of mediæval Rome, would gladly call off interest from the unremunerative labors which are prompted only by the thirst for knowledge and faith in the possibility of learning more and more of the divine order of the world, to pursuits which bring obvious and material utility. There are those again who, fearing (as I think foolishly) that increasing knowledge of this divine order will lower our admiration of its beauty, or that the better a man understands the laws of God the more likely he is to break them, have an unfeigned dislike for natural science in general, and for biology in particular. They repeat over again the error of which the Dominican friars, with far greater excuse, were guilty when they imprisoned Galileo. If any such are here, may I venture to tell them—in quietness and in confidence is your strength: the vast fabric of Christian morals is in no danger of being overturned by the discovery of a new chemical method in the laboratory, or of a hitherto undescribed animalcule. If noisy attacks are made in the injured name of science, you have only to wait, and you will see these attacks repelled by the true leaders of science themselves, or, at the worst, by the next generation. But if, leaving your secure fortress of defense, you come down with your rhetoric and your sentiments, your *petitio principii*, your *ignoratio elenchi*, and all your familiar fallacies and tropes, thinking that with such weapons you can meet, on their own ground, men who have spent their lives in the study of science, then no wonder if you suffer grievous defeat. Happy for you if you learn, like another discomfited pilgrim, to betake yourselves to another "weapon."

But I imagine that some of my audience are saying: "This defense would have been necessary before the Royal Commission made their report; but when that was made, and affirmed the necessity of physiological experiments, and the groundlessness of accusations of cruelty against physiologists, when an act was passed which licenses physiological laboratories, under the very restrictions which you had already imposed upon yourselves, may we not regard the controversy as closed, and the result as satisfactory?"

I answer that I have taken up your time with this defense of physiological experiments partly because I would fain help, however feebly, in the enlightenment of the public conscience, but also because the result of recent legislation is *not* satisfactory.

Science does not work readily in fetters. A system of licenses and certificates, numerous and complicated, obtained with trouble and delay, and revocable at the will of a minister who may, by the accidents of party, be at any time amenable to anti-scientific influences,

such a system adds serious difficulties to those already in the way of experiments.

Suppose, as an illustration, that certain persons opposed on various grounds to learning, and especially hostile to Greek, had attacked the study of Plato. They would point out the danger of modern ladies becoming as well read in his writings as was Lady Jane Grey. They would show that the laxity of modern manners was coincident with the popularity of the "Symposium," and that the notorious increase of infanticide was the result of the teaching of the "Republic." Associations for the total suppression of Plato would be formed, with hired advocates, and anonymous letters, and "leaflets," spreading a knowledge of his most objectionable passages. Scholars would be threatened with eternal punishment, and schoolmasters with the withdrawal of their pupils. Then a royal commission would be appointed—a great Latin scholar, a Whig, and a Tory statesman (who, having taken a B. Sc. degree at Oxford would be impartially ignorant of Greek), the most intelligent despiser of Plato who could be found, the master of a grammar-school on the modern side, and (perhaps the most efficient of all) a lawyer, who knew nothing about Greek, but hated cant. This commission would take evidence that the Platonic writings were not all immoral, that they had been quoted with approval by Fathers of the Church, that they were of great importance to literature and philosophy, and even to the elucidation of the Sacred Writings. It would also be proved that the Platonic dialogues were far less immoral than multitudes of other widely circulated books, or than a French novel which one of the royal commissioners happened to be reading; and, lastly, that the morals of Greek scholars, and of clergymen who had read Plato at college, were not obviously degraded below those of other people. On the other hand, witnesses would depose that a knowledge of Plato was of no consequence to a student of philosophy; that, if it were, the text was in so corrupt a condition that no two scholars agreed as to a single chapter, and that, after all, philosophy was of no practical use, least of all to clergymen. Others would affirm that, though they had never read a line of him, they knew that his style was as vicious as his sentiments; and perhaps some cross-grained scholar might be found who, having once edited a play of Euripides, would declare that all studies in Greek literature ought to be restricted to the tragedians, and that for his part he had never opened any other authors and had never felt the want of them.

At last the commission would report that there was no question of the value of the works of Plato, that it would be mischievous and impracticable to prohibit their study, and that there was no evidence that schoolmasters habitually chose the least edifying passages as lessons for boys. Then what is called a compromise would be made. It would be enacted that Plato might be read, but only in colleges annually licensed for that purpose; that every one wishing to read must

have a general certificate signed by certain professors, and setting forth his object, also to be renewed every year; and that special certificates might be severally obtained for reading certain excepted dialogues, for copying from them, for publishing them, or, in rare cases, for translating them.

However reasonably such a system might be administered, who can doubt the result would be a diminution of the number of scholars, and a check to the progress of learning?

Now this is what legislation has done for physiological experiments. The act (39 and 40 Victoria) was hastily drawn and hurriedly discussed; for noble lords and honorable gentlemen who had been taught from childhood to vivisect for unscientific purposes were eager to hurry off to their own merry vivisections, for which they were ready provided with license and certificates. And it works as might be expected. Some shrink from seeing their names figure in disreputable newspapers, and receiving more or less savagely abusive anonymous letters. Others have no laboratories, and find difficulty in licensing their houses. Others are refused the certificates they require.

In one case two thoroughly qualified men were anxious to carry out an important investigation on the treatment of snake-bites. They procured venomous snakes from a distance, and applied for the special certificates necessary. Considerable delay ensued; various objections were raised, and set at rest; and at last all the certificates were obtained; but meantime the snakes had died.

MYTHOLOGIC PHILOSOPHY.*

By Major J. W. POWELL.

II.

IV.—Outgrowths from Mythologic Philosophy.

THE three stages of mythologic philosophy that are still extant in the world must be more thoroughly characterized, and the course of their evolution indicated. But in order to do this clearly, certain outgrowths from mythologic philosophy must be explained, certain theories and practices that necessarily result from this philosophy, and that are intricately woven into the institutions of mankind.

Ancientism.—The first I denominate ancientism. Yesterday was better than to-day. The ancients were wiser than we. This belief in a better day and a better people in the elder time is almost universal among mankind. A belief so widely spread, so profoundly enter-

* An Address delivered before the American Association for the Advancement of Science, at Saratoga, New York, August 29, 1879, by Major J. W. Powell, Vice-President of Section B.

tained, must have for its origin some important facts in the constitution or history of mankind. Let us see what they are.

In the history of every individual, the sports and joys of childhood are compared and contrasted with the toils and pains of old age. Greatly protracted life, in savagery and barbarism, is not a boon to be craved. In that stage of society where the days and the years go by with little or no provision for a time other than that which is passing, the old must go down to the grave through poverty and suffering. In that stage of culture to-morrow's bread is not certain, and to-day's bread is often scarce. In civilization, plenty and poverty live side by side; the palace and the hovel are on the same landscape; the rich and poor elbow each other on the same street: but, in savagery, plenty and poverty come with recurring days to the same man, and the tribe is rich to-day and poor to-morrow, and the days of want come in every man's history, and when they come the old suffer most, and the burden of old age is oppressive. In youth, activity is joy; in old age, activity is pain. No wonder, then, that old age loves youth, or that to-day loves yesterday, for the instinct is born of the inherited experiences of mankind.

But there is yet another and more potent reason for ancientism. That tale is the most wonderful that has been most repeated, for the breath of speech is the fertilizer of story. Hence, the older the story, the greater its thaumaturgics. Thus, yesterday is greater than to-day by natural processes of human exaggeration. Again, that is held to be most certain, and hence most sacred, which has been most often affirmed. A Brahman was carrying a goat to the altar. Three thieves would steal it. So they placed themselves at intervals along the way by which the pious Brahman would travel. When the venerable man came to the first thief he was accosted: "Brahman, why do you carry a dog?" Now, a dog is an unclean beast which no Brahman must touch. And the Brahman, after looking at his goat, said: "You do err; this is a goat." And when the old man reached the second thief, again he was accosted: "Brahman, why do you carry a dog?" So the Brahman put his goat on the ground, and after narrowly scrutinizing it, he said, "Surely this is a goat," and went on his way. When he came to the third thief he was once more accosted: "Brahman, why do you carry a dog?" Then the Brahman having thrice heard that his goat was a dog, was convinced, and throwing it down, he fled to the temple for ablution, and the thieves had a feast.

The child learns not for himself, but is taught, and accepts as true that which is told, and a propensity to believe the affirmed is implanted in his mind. In every society some are wise and some are foolish, and the wise are revered, and their affirmations are accepted. Thus, the few lead the multitude in knowledge, and the propensity to believe the affirmed started in childhood is increased in manhood in the great average of persons constituting society, and these propensities are in-

herited from generation to generation, until we have a cumulation of effects.

The propagation of opinions by affirmation, the cultivation of the propensity to believe that which has been affirmed many times, let us call *affirmatization*. If the world's opinions were governed only by the principles of mythologic philosophy, affirmatization would become so powerful that nothing would be believed but the anciently affirmed. Men would come to know new knowledge. Society would stand still listening to the wisdom of the fathers. But the power of affirmatization is steadily undermined by science.

And, still again, the institutions of society conform to its philosophy. The explanation of things always includes the origin of human institutions. So the welfare of society is based on philosophy, and the venerable sayings which constitute philosophy are thus held as sacred. So ancientism is developed from accumulated life-experiences; by the growth of story in repeated narration; by the steadily increasing power of affirmatization, and by respect for the authority upon which the institutions of society are based; all accumulating as they come down the generations. That we do thus inherit effects we know, for has it not been affirmed in the Book that "the fathers have eaten grapes, and the children's teeth are set on edge"? As men come to believe that the "long ago" was better than the "now," and the dead were better than the living, then philosophy must necessarily include a theory of degeneracy, which is a part of ancientism.

Theistic Society.—Again, the actors in mythologic philosophy are personages, and we always find them organized in societies. The social organization of mythology is always found to be essentially identical with the social organization of the people who entertain the philosophy. The gods are husbands and wives, and parents and children, and the gods have an organized government. This gives us theistic society, and we can not properly characterize a theism without taking its mythic society into consideration.

Spiritism.—In the earliest stages of society of which we have practical knowledge by acquaintance with the people themselves, a belief in the existence of spirits prevails—a shade, an immaterial existence, which is the duplicate of the material personage. The genesis of this belief is complex. The workings of the human mind during periods of unconsciousness lead to opinions that are enforced by many physical phenomena.

First, we have the activities of the mind during sleep, when the man seems to go out from himself, to converse with his friends, to witness strange scenes, and to have many wonderful experiences. Thus the man seems to have lived an eventful life, when his body was, in fact, quiescent and unconscious. Memories of scenes and activities in former days, and the inherited memories of scenes witnessed and actions performed by ancestors, are blended in strange confusion by

broken and inverted sequences. Now and then the dream-scenes are enacted in real life, and the infrequent coincidence or apparent verification makes deep impression on the mind, while unfulfilled dreams are forgotten. Thus the dreams of sleepers are attributed to their immaterial duplicates—their spirits. In many diseases, also, the mind seems to wander, to see sights, and to hear sounds, and to have many wonderful experiences, while the body itself is apparently unconscious. Sometimes on restored health, the person may recall these wonderful experiences, and during their occurrence the subject talks to unseen persons, and seems to have replies and to act, to those who witness, in such a manner that a second self—a spirit independent of the body—is suggested. When disease amounts to long-continued insanity, all of these effects are greatly exaggerated, and make a deep impression upon all who witness the phenomena. Thus the hallucinations of fever-racked brains, and mad minds, are attributed to spirits.

The same conditions of apparent severance of mind and body witnessed in dreams and hallucinations are often produced artificially in the practice of *ecstacism*. In the vicissitudes of savage life, while little or no provision is made for the future, there are times when the savage resorts to almost anything at hand as a means of subsistence, and thus all plants and all parts of plants, seed, fruit, flowers, leaves, bark, roots—anything in times of extreme want—may be used as food. But experience soon teaches the various effects upon the human system which are produced by the several vegetable substances with which he meets, and thus the effect of narcotics is early discovered, and the savage in the practice of his religion oftentimes resorts to these native drugs for the purpose of producing an ecstatic state under which divination may be performed. The practice of ecstacism is universal in the lower stages of culture. In times of great anxiety, every savage and barbarian seeks to know of the future. Through all the earlier generations of mankind, ecstacism has been practiced, and civilized man has thus an inherited appetite for narcotics to which the enormous propensity to drunkenness existing in all nations bears witness. When the great actor in his personation of Rip Van Winkle holds his goblet aloft and says, "Here's to your health and to your family's, and may they live long and prosper," he connects the act of drinking with a prayer, and unconsciously demonstrates the origin of the use of stimulants. It may be that when the jolly companion has become a loathsome sot, and his mind is ablaze with the fire of drink, and he sees uncouth beasts in horrid presence, that inherited memories haunt him with visions of the beast-gods worshiped by his ancestors at the very time when the appetite for stimulants was created. But ecstacism is produced in other ways, and for this purpose the savage and barbarian often resorts to fasting and bodily torture. In many ways he produces the wonderful state, and the visions of ecstasy are interpreted as the evidence of spirits.

Many physical phenomena serve to confirm this opinion. It is very late in philosophy when shadows are referred to the interception of the rays of the sun. In savagery and barbarism shadows are supposed to be emanations from or duplicates of the bodies causing the shadows. And what savage understands the reflection of the rays of the sun by which images are produced? They also are supposed to be emanations or duplications of the object reflected. No savage or barbarian could understand that the waves of the air are turned back and sound is duplicated in an echo. He knows not that there is an atmosphere, and to him the echo is the voice of an unseen personage—a spirit. There is no theory more profoundly implanted in early mankind than that of spiritism.

Thaumaturgics.—The gods of mythologic philosophies are created to account for the wonders of nature. Necessarily they are a wonder-working folk, and having been endowed with these magical powers in all the histories given in mythic tales of their doings on the earth, we find them performing most wonderful feats. They can transform themselves; they can disappear and reappear; all their senses are magical; some are endowed with a multiplicity of eyes, others have a multiplicity of ears; in Norse mythology the watchman on the rainbow bridge could hear the grass grow and the wool on the backs of sheep; arms can stretch out to grasp the distance, tails can coil about mountains, and all powers become magical. But the most wonderful power with which the gods are endowed is the power of will, for we find that they can think their arrows to the hearts of their enemies; mountains are overthrown by thought, and thoughts are projected into other minds. Such are the thaumaturgics of mythologic philosophy.

Mythic Tales.—Early man having created through the development of his philosophy a host of personages, these gods must have a history. A part of that history, and the most important part to us as students of philosophy, is created in the very act of creating the gods themselves. I mean that portion of their history which relates to the operations of nature, for the gods were created to account for those things. But to this is added much else of adventure. The gods love as men love, and go in quest of mates. The gods hate as men hate, and fight in single combat or engage in mythic battles; and the history of these adventures impelled by love and hate, and all other passions and purposes with which men are endowed, all woven into a complex tissue with their doings in carrying out the operations of nature, constitutes the web and woof of mythology.

Religion.—Again, as human welfare is deeply involved in the operations of nature, man's chief interest is in the gods. In this interest religion originates. Man, impelled by his own volition, guided by his own purposes, aspires to a greater happiness, and endeavor follows endeavor, but at every step his progress is impeded: his own powers fail before the greater powers of nature; his powers are pygmies, na-

ture's powers are giants, and to him these giants are gods with wills and purposes of their own, and he sees that man in his weakness can succeed only by allying himself with the gods. Hence, impelled by this philosophy, man must have communion with the gods, and in this communion he must influence them to work for himself. Hence, religion, which has to do with the relations which exist between the gods and man, is the legitimate offspring of mythologic philosophy.

Thus we see that out of mythologic philosophy, as branches of the great tree itself, there grow ancientism, theistic society, spiritism, thaumaturgics, mythic tales, and religion.

V.—The Evolution of Mythologic Philosophy.

I shall now give a summary characterization of zoötheism, then call attention to some of the relics of hecastotheism found therein, and proceed with a brief statement of the higher stages of theism. The apparent and easily accessible is studied first. In botany, the trees and the conspicuous flowering plants of garden, field, and plain were first known, and then all other plants were vaguely grouped as weeds; but, since the most conspicuous phenogamous plants were first studied, what vast numbers of new orders, new genera, and new species have been discovered, in the progress of research, to the lowest cryptogams!

In the study of ethnology, we first recognized the more civilized races. The Aryan, Hamites, Shemites, and Chinese, and the rest were the weeds of humanity—the barbarian and savage, sometimes called Turanians. But, when we come carefully to study these lower people, what numbers of races are discovered! In North America alone we have more than seventy-five—seventy-five stocks of people speaking seventy-five stocks of language, and some single stocks embracing many distinct languages and dialects. The languages of the Algonquin family are as diverse as the Indo-European tongues. So are the languages of the Dakota, the Numa, the Tinné, and others; so that in North America we have more than five hundred languages spoken today. Each linguistic stock is found to have a philosophy of its own, and each stock as many branches of philosophy as it has languages and dialects. North America presents a magnificent field for the study of savage and barbaric philosophies.

This vast region of thought has been explored only by a few adventurous travelers in the world of science. No thorough survey of any part has been made. Yet the general outlines of North American philosophy are known, but the exact positions, the details, are all yet to be filled in—as the geography of the general outline of North America is known by exploration, but the exact positions and details of topography are yet to be filled in as the result of careful survey. Myths of the Algonquin stock are found in many a volume of *Americana*, the best of which were recorded by the early missionaries who came from Europe, though we find some of them, mixed with

turbid speculations, in the writings of Schoolcraft. Many of the myths of the Indians of the South, in that region stretching back from the great Gulf, are known—some collected by travelers, others by educated Indians.

Many of the myths of the Iroquois are known. The best of these are in the writings of Morgan, America's greatest anthropologist. Missionaries, travelers, and linguists have given us a great store of the myths of the Dakota stock. Many myths of the Tinné also have been collected. Petitot has recorded a number of those found at the North, and we have in manuscript some of the myths of a Southern branch—the Navajos. Perhaps the myths of the Numas have been collected more thoroughly than those of any other stock. These are yet unpublished. Powers has recorded many of the myths of various stocks in California, and the old Spanish writings give us a fair collection of the Nahuatl myths of Mexico, and Rink has presented us an interesting volume on the mythology of the Innuits; and, finally, fragments of mythology have been collected from nearly all the tribes of North America, and they are scattered through thousands of volumes, so that the literature is vast. The brief description which I shall give of zoötheism is founded on a study of the materials which I have thus indicated.

All these tribes are found in the higher stages of savagery, or the lower stages of barbarism, and their mythologies are found to be zoötheistic among the lowest, physitheistic among the highest, and a great number of tribes are found in a transition state, for zoötheism is found to be a characteristic of savagery, and physitheism of barbarism, using the terms as they have been defined by Morgan. The supreme gods of this stage are animals. The savage is intimately associated with animals. "From them he obtains the larger part of his clothing, and much of his food, and he carefully studies their habits and finds many wonderful things. Their knowledge and skill and power appear to him to be superior to his own. He sees the mountain-sheep fleet among the crags, the eagle soaring in the heavens, the humming-bird poised over its blossom-cup of nectar, the serpents swift without legs, the salmon scaling the rapids, the spider weaving its gossamer web, the ant building a play-house mountain—in all animal nature he sees things too wonderful for him, and from admiration he grows to adoration, and the animals become his gods." *

Ancientism plays an important part in this zoötheism. It is not the animals of to-day whom the Indians worship, but their progenitors —their prototypes. The wolf of to-day is a howling pest, but that wolf's ancestor—the first of the line—was a god. The individuals of every species are supposed to have descended from an ancient being—

* *Vide* "Outlines of the Philosophy of the North American Indians," by J. W. Powell. Read before the American Geographical Society at Chickering Hall, December 29, 1876.

a progenitor of the race; and so they have a grizzly-bear-god, an eagle-god, a rattlesnake-god, a trout-god, a spider-god—a god for every species and variety of animal.

By these animal-gods all things were established. The heavenly bodies were created and their ways appointed, and when the powers and phenomena of nature are personified, the personages are beasts, and all human institutions also were established by the ancient animal-gods.

The ancient animals of any philosophy of this stage are found to constitute a clan or *gens*—a body of relatives, or *consanguinii*, with grandfathers, fathers, sons, and brothers. In Ute theism, the ancient Togoav, the first rattlesnake, is the grandfather, and all the animal-gods are assigned to their relationships. Grandfather Togoav, the wise, was the chief of the council, but Shinauav, the ancient wolf, was the chief of the clan.

There were many other clans and tribes of ancient gods with whom these supreme gods had dealings, of which hereafter; and, finally, each of these ancient gods became the progenitor of a new tribe, so that we have a tribe of bears, a tribe of eagles, a tribe of rattlesnakes, a tribe of spiders, and many other tribes, as we have tribes of Utes, tribes of Sioux, tribes of Navajos: and in that philosophy tribes of animals are considered to be coördinate with tribes of men. All of these gods have invisible duplicates—spirits—and they have often visited the earth. All of the wonderful things seen in nature are done by the animal-gods. That elder life was a magic life; but the descendants of the gods are degenerate. Now and then as a medicine-man by practicing sorcery can perform great feats, so now and then there is a medicine-bear, a medicine-wolf, or a medicine-snake that can work magic.

On winter nights, the Indians gather about the camp-fire, and then the doings of the gods are recounted in many a mythic tale. I have heard the venerable and impassioned orator on the camp-meeting stand rehearse the story of the crucifixion, and have seen the thousands gathered there weep in contemplation of the story of divine suffering, and heard their shouts roll down the forest aisles as they gave vent to their joy at the contemplation of redemption. But the scene was not a whit more dramatic than another I have witnessed in an evergreen forest of the Rocky Mountain region, where a tribe was gathered under the great pines, and the temple of light from the blazing fire was walled by the darkness of midnight, and in the midst of the temple stood the wise old man telling in simple savage language the story of Tawats, when he conquered the sun and established the seasons and the days. In that pre-Columbian time, before the advent of white men, all the Indian tribes of North America gathered on winter nights by the shores of the seas where the tides beat in solemn rhythm, by the shores of the great lakes, where the waves dashed

against frozen beaches, and by the banks of the rivers flowing ever in solemn mystery—each in its own temple of illumined space—and listened to the story of its own supreme gods, the ancients of time.

Religion, in this stage of theism, is sorcery. Incantation, dancing, fasting, bodily torture, and ecstacism are practiced. Every tribe has its potion or vegetable drug, by which the ecstatic state is produced, and their venerable medicine-men see visions and dream dreams. No enterprise is undertaken without consulting the gods, and no evil impends but they seek to propitiate the gods. All daily life, to the minutest particular, is religious. This stage of religion is characterized by fetichism. Every Indian is provided with his charm or fetich, revealed to him in some awful hour of ecstasy produced by fasting, or feasting, or drunkenness, and that fetich he carries with him to bring good luck, in love or in combat, in the hunt or on the journey. He carries a fetich suspended to his neck, he ties a fetich to his bow, he buries a fetich under his tent, he places a fetich under his pillow of wild-cat skins, he prays to his fetich, he praises it, or chides it; if successful, his fetich receives the glory; if he fail, his fetich is disgraced. These fetiches may be fragments of bone or shell, the tips of the tails of animals, the claws of birds or beasts, perhaps dried hearts of little warblers, shards of beetles, leaves powdered and held in bags, or crystals from the rocks—anything curious may become a fetich. Fetichism, then, is a religious means, not a philosophic or mythologic state. Such are the supreme gods of the savage, and such the institutions which belong to their theism. But they have many other inferior gods. Mountains, hills, valleys, and great rocks have their own special deities—invisible spirits—and lakes, rivers, and springs are the homes of spirits. But all these have animal forms when in proper *personæ*. Yet some of the medicine-spirits can transform themselves, and work magic as do medicine-men. The heavenly bodies are either created personages or ancient men or animals translated to the sky. And, last, we find that ancestors are worshiped as gods.

Among all the tribes of North America, with which we are acquainted, tutelarism prevails. Every tribe and every clan has its own protecting god, and every individual has his "my god." It is a curious fact that every Indian seeks to conceal the knowledge of his "my god" from all other persons, for he fears that, if his enemy should know of his tutelar deity, he might by extraordinary magic succeed in estranging him, and be able to compass his destruction through his own god.

In this summary characterization of zoötheism, I have necessarily systematized my statements. This, of course, could not be done by the savage himself. He could give you its particulars, but could not group those particulars in any logical way. He does not recognize any system, but talks indiscriminately, now of one, now of another god, and with him the whole theory as a system is vague and shad-

owy, but its particulars are vividly before his mind, and the certainty with which he entertains his opinions leaves no room to doubt his sincerity.

But there is yet another phase of theism discovered. Sometimes a particular mountain, or hill, or some great rock, some waterfall, some lake, or some spring receives special worship, and is itself believed to be a deity. This seems to be a relic of hecastotheism. Fetichism, also, seems to have come from that lower grade, and all the minor deities, the spirits of mountains and hills and forests, seem to have been derived from that same stage, but with this development, that the things themselves are not worshiped, but their essential spirits.

From zoötheism, as described, to physitheism the way is long. Gradually, in the progress of philosophy, animal-gods are dethroned and become inferior gods or are forgotten; and gradually the gods of the firmament—the sun, the moon, the stars—are advanced to supremacy: the clouds, the storms, the winds, day and night, dawn and gloaming, the sky, the earth, the sea, and all the various phases of nature perceived by the barbaric mind, are personified and deified and exalted to a supremacy coördinate with the firmament gods; and all the gods of the lower stage that remain—animals, demons, and all men—belong to inferior tribes. The gods of the sky—the shining ones, those that soar on bright wings, those that are clothed in gorgeous colors, those that came from we know not where, those that vanish to the unknown—are the supreme gods. We always find these gods organized in great tribes, with mighty chieftains who fight in great combats or lead their hosts in battle, and return with much booty. Such is the theism of ancient Mexico, such the theism of the Northland, and such the theism discovered among the ancient Aryans.

From this stage to psychotheism the way is long, for evolution is slow. Gradually men come to differentiate more carefully between good and evil, and the ethic character of their gods becomes the subject of consideration, and the good gods grow in virtue, and the bad gods grow in vice. Their identity with physical objects and phenomena is gradually lost. The different phases or conditions of the same object or phenomenon are severed, and each is personified. The bad gods are banished to underground homes, or live in concealment, from which they issue on their expeditions of evil. Still, all powers exist in these gods, and all things were established by them. With the growth of their moral qualities no physical powers are lost, and the spirits of the physical bodies and phenomena become demons, subordinate to the great gods who preside over nature and human institutions.

We find, also, that these superior gods are organized in societies. I have said the Norse mythology was in a transition state from physitheism to psychotheism. The Asas, or gods, lived in Asgard, a

mythic communal village, with its Thing or Council, the very counterpart of the communal village of Iceland. Olympus was a Greek city.

Still further in the study of mythologic philosophy we see that more and more supremacy falls into the hands of the few, until monotheism is established on the plan of the empire. Then all of the inferior deities whose characters are pure become ministering angels, and the inferior deities whose characters are evil become devils, and the differentiation of good and evil is perfected in the gulf between heaven and hell. In all this time from zoötheism to monotheism, ancientism becomes more ancient, and the times and dynasties are multiplied. Spiritism is more clearly defined, and spirits become eternal; mythologic tales are codified, and sacred books are written; divination for the result of amorous intrigue has become the prophecy of immortality, and thaumaturgics is formulated as the omnipotent, the omnipresent, and the infinite.

Time has failed me to tell of the evolution of idolatry from fetichism, priestcraft from sorcery, and of their overthrow by the doctrines that were uttered by that voice on the Mount. Religion, that was fetichism and ecstacism and sorcery, is now the yearning for something better, something purer, and the means by which this highest state for humanity may be reached, the ideal worship of the highest monotheism, is "in spirit and in truth." The steps are long from Shinauav, the ancient of wolves, by Zeus, the ancient of skies, to Jehovah, the "ancient of days."

Comparative theology furnishes grand illustrations of the processes of evolution. It presents a multiplicity of events occurring in orderly succession in obedience to the laws of adaptation, heredity, and survival of the fittest, and, in passing from the lower to the higher state, it demonstrates the fundamental law of progress, that evolution is from the homogeneous to the heterogeneous by successive differentiations and integrations.

THE EVOLUTION OF A NEW SENSE.

By WILLIAM A. EDDY.

WE find that the degrees of perception in people vary. In other words, one may receive more impressions than another, so that we measure the extent of a person's life by the number of objects or ideas that produce a lasting effect and modify the disposition or mental tendency. This suggests a comparison of the senses in different persons. Then arises the general question of the possible evolution of new powers, for with a wider meaning we may term the telegraph, the printing-press, and particularly the telescope, approximations to

what we may consider new senses. The subject may be thus carried to the higher point concerning the increase of all the mental powers.

In "our little life . . . rounded with a sleep," we are cut off by invisible barriers from even a comprehension of the peculiar tastes for enjoyment manifested by some others. It is difficult to understand Livingston's contentment during a life of exile and exposure. There was in him an inextinguishable mental tendency which appeared in his strange delight in conquering difficulties. But we need not cite an example from the other hemisphere. We see this bias or mental momentum (if a mechanical phrase be allowable in affairs of the mind) all around us. It is true the force is not always effective, but this does not invalidate the reality of this peculiar tendency, which too often shows in how singularly narrow a manner the mental powers act. The minds of men are like circles which allow elongation in a given direction, but at the expense of another part of the circle which contracts in a corresponding degree. The addition of a sixth sense would result in a resource which would not lessen the effectiveness of other faculties by a withdrawal of force to supply the new demand.

That we are mentally inadequate appears in our ever-recurring errors. This narrowness of view is also illustrated by the misunderstandings that arise between ideal and practical men. Some persons who are devoted exclusively to every-day affairs can not easily comprehend how others can look at a printed page and then form imaginary images or be greatly interested in fiction. On the other hand, the imaginative reader is forced to admit the importance of practical people, yet he can not see why they take pleasure in trade, which to the reader of intense literary taste involves necessary monotony—like that of a mill at which tramps in England were forced to grind before they could obtain lodging. The ideal and the practical are apparently at opposite poles, yet the general result conforms to the law of liquids in hydraulics: a proper balance is maintained in spite of particular variations. But this intense progressive action, or bias, on one side or the other, should be distinguished from the primary power which would be added were another subjective connection opened with the objective world. The perceptions of a new sense would be positive, like those of our present senses, and would in no manner seem the result of effort or of the skill that comes by practice.

Mr. Gladstone, in an article contributed to the "Nineteenth Century," tried to demonstrate theoretically that the perception of color among the ancients was especially defective. In support of this he cited numerous passages from Homer as showing that the great Greek poet could not distinguish fine shades of color. After noticing Homer's comparison of the objects in nature with the colors of animals, he argues that a person with the average modern eye for the perception of color would not have made such comparisons without being aware of their inaccuracy. But he does not maintain that every-

body in Homer's time was color-blind. He simply quotes many passages from Greek literature as supporting his position that, we will say, where one person is color-blind now, nine were color-blind then. Looked at hastily, this question of color seems of small importance. But let us look carefully. Is it not startling to think that the primary senses may be widening? It would follow, if additional evidence should be found to sustain Mr. Gladstone's theory, that the highly civilized portions of the human race are capable of perceiving finer shades of color, owing to a more delicate material development of the sense of sight. Once admit the development of one of the senses to be a demonstrated process, and the door is opened to tremendous consequences and possibilities of power, and consequently to a wider scope for the soul in the coming generations of men. For comprehension of the methods of Nature inevitably results in that form of control which opens the way to further perceptions.

In some respects the development of the senses is not quite as inconceivable as it may at first appear. The following analogies can hardly be considered sufficiently connected by evidence to be properly called theories, yet they are only relatively visionary. For example, imagine that we should acquire the power to become aware of the smallest change of material particles many miles away. Tait and Stewart have ingeniously argued that, according to the law of attraction, the slightest vibration or change of particles in the human brain during thought infinitesimally influences the remotest fixed star. This does not appear wildly theoretical, because it is mathematically demonstrable to the imagination. The visionary theory is in supposing that owing to corresponding vibrations of nerve-fiber we would be definitely conscious of distant material changes. This would result in a form of universal consciousness and consequent confusion, unless the perception were specialized in the form of a concentrated effort. The singular analogy is that the effect arising from the mutually attractive vibrations of particles would resemble the process by which sound reaches us—an accordance of the vibration of the ear-drum with that of the air. George Henry Lewes has shown that "the physiologist can lawfully speak of unconscious sensations as the physicist can speak of invisible rays of light—meaning those rays which are of a different order of undulation from the visible rays, and which may become visible when the susceptibility of the retina is exalted." This is in part applicable to Mr. Gladstone's theory of the development of the perception of color. It is believed that the heat-rays of the sun, largely consisting of what are called the dark rays, do not produce a luminous effect, simply because the vibrations of the nerve-substance of the retina are not in unison with the invisible ray. In the same way the perception of color may involve a special series of vibrations absent in color-blind persons. Then arises the question here noticed, as to whether the sensation of color

is owing to individual education, or is the result of slow and continuous physiological evolution during thousands of years. Owing to lack of evidence the question seems at present unanswerable. But it is obvious that our present senses might reveal more to us, because we are inferior to many animals in detecting objects by smell, hearing, or sight. Our comparative dullness is apparently due to the fact that there is with us no incessantly impending danger, and in consequence some of these senses are not as often excited.

It is unquestionably our wish that we could have greater powers of discernment. The telegraph and printing-press are indications of this longing for a wider life. Science has taught us that we perceive only an infinitesimal part of the objective world and of its processes. The theoretical addition of another sense does not satisfy us. It would seem only a new working-wheel of the mechanism. In fact, greatly magnified powers of perception without the assistance of instruments seem possible only through slow methods of development. If a sixth sense should confer upon us with our present range of faculties the power to be everywhere at once, we would be reduced to a state of confusion equivalent to the nullification of consciousness. The attempt to conceive it results in absurd contradictions. It is precisely this condition of omnipresence which is vaguely imagined as possible in clairvoyance. One of the difficulties in regard to accepting clairvoyance as an indication of a sixth sense is that the effect arises from a diseased condition of the sensibility. The result is unaccountable, but at the same time unwholesome. It is at variance with the steadily increasing scientific knowledge of our day in the fact that its phenomena evade verification or reduction to a consistent law of action. Men have been learning for the past five thousand years or more that physical or mental work and obedience to natural law increase the force and effectiveness of the individual and of his descendants. The geological discoveries of Huxley and Marsh, and the development of the simplest forms of vegetable life, denote an irresistible evolutionary sequence or working power in nature. It seems as necessary that those animals with the greatest power of adaptation should survive and express the later result, as that, to use Spinoza's geometrical illustration, the sum of the angles of a triangle should equal two right angles. And it is probable that a finer and higher grade of perceptions would not be altogether through the physiological development of our present senses, because such senses imply an inevitable relation or result from the action of the outer world ; but many such perceptions would be due to a greater command of material potencies—such as that outlined in the possible extension of knowledge through the telephone, the phonograph, or the liquefaction of all the gases.

Among the many singular and original ideas attributed to Edgar A. Poe, was one to the effect that during a silence of about twenty minutes it is possible to know an intimate friend's line of thought as

well as if the ideas had taken form in words. In order to be successful, this would require a very intimate acquaintance with the friend's habits of thought. In fact, we all try to interpret the thoughts of others during silence, but we are generally wide of the mark, because we do not know the peculiar law of association of ideas applicable to each person. There is a general process by which one idea suggests another in all minds, but there are also particular variations. Nevertheless, unless the person is on his guard, fully seventy-five per cent. of his ideas will be known to any one who is accustomed to following the thoughts of others. The first thoughts, which arise in the mind automatically, are limited in number, because the connection with more remote ideas has not yet been made. It is probable that with increased knowledge of the peculiar laws of mental action, great skill will be shown in thus following the ideas of others, and it is clear that such a science of mind-reading would be built upon metaphysical data, just as mathematical data are now necessary factors in estimating the distance and motion of a planet. In some respects the limit of mental penetration may not be as absolute as we imagine. It is certainly not advisable to set limits like those astronomers who claimed that they had discovered the center around which the visible universe is revolving in a mighty orbit. It was found that this so-called center was describing a vast arc of a circle around another center inconceivably distant. The discoveries of the past indicate that others as important are to be made. The horizon recedes, revealing new objects.

In the light of past discoveries it seems highly improbable that so important a physiological gift as a sixth sense could come to us suddenly and mysteriously. This is not the manner in which Nature works. Everything is paid for, and our advantages come only from work and its accompanying natural growth, or by the hereditary transmission of a fortunate balance of powers in a line of ancestors. The first impulse arises from the necessity of work, and from the actions of events which stimulate the ingenuity. The increased activity is accompanied by an increase of fiber or power of continuance. Tyndall has admirably illustrated the fact that this law of mental supply and demand applies with precision to the processes of nature: "No particle of vapor was formed and lifted without being paid for in solar heat. There is nothing gratuitous in physical nature, no gain without equivalent expenditure." It is our tendency to look for theatrical or imposing manifestations of human power not paid for by work, and when a result appears mysterious owing to our ignorance of its source, we too often settle the difficulty in accordance with a convenient and visionary theory. In this way we hear a coincidence called a prophetic dream. No one has adequately estimated the enormous number of dreams that drift through the mind during a lifetime, and when a dream coincides in a measure with an event which takes place long afterward, the assumption then is that some dreams are of a pro-

phetic nature. It seems clear that the only element of prophecy is due to a coincidence or similarity between the dream and the event. The minute particulars missing from the dream will be filled in by the imagination almost unconsciously, because the events of the dream and the real events become confused in the recollection.

All this does not divest the unknown of its mysterious possibilities. But there is a striking contrast between the so-called unaccountable results of clairvoyance and mesmerism, in their relation to transcendental knowledge, and the theories of science founded upon verified experiments. The obscurity or apparent mystery of the scientific theory steadily decreases with each addition of evidence, until the astonishing possibility "hardens into a fact." The clairvoyant theory not only evades all attempts to analyze it, but utterly fails in regard to any valuable results which could serve as starting-points for future discovery. The coming fact at once seems "reasonable and real," and does not rest upon the mere belief of one person. It can be verified from more than one point of view, and carries with it the convincing force of an axiom. Emerson, in his lecture in the Old South Church, Boston, on February 24, 1878, finely said, "The gracious lesson taught by science to this country is, that the history of nature from first to last is incessant advance from less to more, from rude to finer organization, the globe of matter thus conspiring with the principle of undying hope in man."

We must look to the onward march of progressive development for new power, and not to the mysterious and so far valueless results of clairvoyance, with its examples of trickery or nervous organisms thrown out of balance. There is more of the spiritual element in a beautiful sunset than in the table-rapping and other dramatic effects of animal magnetism or jugglery.

WHY DO SPRINGS AND WELLS OVERFLOW?

By NELSON W. GREEN.

SINCE water tends to find a level, we infer that flowing water is acting in harmony with this natural law, unless it be put in motion by some equivalent force. The overflowing of wells and springs has hitherto been accounted for by scientists only upon the supposed existence of hydrostatic pressure. But a more careful investigation seems to justify the conclusion that, while in exceptional cases this may occur, yet as a proposition it is fallacious, and it will be the aim of the following discussion to expose the fallacy.

In 1844 Rev. William Buckland, Professor of Geology at Oxford,

England, was invited, on account of his learning and character, to give an address, in which he made the following statements:* "Wells sunk to a greater depth through stratified rocks often afford large supplies, but rarely rise to the surface; and in cases where they do so they are called artesian wells, from the circumstance of such artificial flowing wells being common in Artois (France). In all these cases [among which the Professor included the flowing wells at Grenelle, near Paris] the water was forced up by hydrostatic pressure to various distances from the surface. At Brentford, England, there were many wells that continually overflowed their orifice, which is a few feet only above the Thames. In the London wells the water rises to a less level than in those at Brentford."

By hydrostatic pressure, the Professor, of course, means a head, i. e., that the water flowed to these wells from a higher point. If this rise were due to hydrostatic pressure, why did the water rise to a lower level at London than at Brentford among the hills? Professor Buckland continues: "In November, 1840, notice was given of an application to Parliament to obtain a new supply of water for London from wells and water-works to be made at Wetford in the chalk-hills. A company had been proposed to effect this object, which would probably have been carried out, had not Mr. Clutterbuck demonstrated, by a long-continued series of measurements of the water in the chalk-hills of Hertfordshire, near Wetford, that every drop of water taken from that neighborhood would have been abstracted from the summer and autumn supplies of the river Coln and would have robbed the proprietors of more than thirty mills upon this river and its tributaries, and the owners of adjacent water-meadows, of rights they had had from time immemorial. One intelligent manufacturer, Mr. Dickinson, had, during many years, found arithmetical evidence that the quantity of summer water in the river Coln varied with the rain in the preceding winter. He could always tell, at the end of February or March, what water there would be in the following eight or nine months; and he regulated the contracts he made in every spring, for paper to be delivered in the summer and autumn, by the quantity of water in his winter rain-gauge. This rain-gauge, the invention of Dalton, being buried three feet below the surface, showed that except in December, January, and February, rain-water rarely descended more than three feet below the soil, so as to add anything to the supply that sinks into the earth to issue during summer, and from springs and rivers; and, whenever Mr. Dickinson found by this instrument that but little rain had fallen in the three months of winter, he proportionally limited his contracts for the following summer and autumn, thus proving the practical advantage of inductions from philosophy."

The following abstract from Professor Buckland's speech may also be in order: "As persons who have no experience in these subjects

* Copied into vol. iii., p. 70, of "Littell's Living Age," from the "Edinburgh Journal."

may be surprised at the knowledge geologists profess to have acquired respecting the internal structure of the earth, he (the Professor) would endeavor to confirm the above theoretical explanation of the origin and supply of springs by appealing to practical proofs in the proceedings of water companies and well-diggers, and in the pounds, shillings, and pence in the ledgers of manufacturers." It certainly must be a matter of "surprise" to most people that, while the rain-water rarely sank deeper than three feet into the soil, it could yet influence the water-supply to be drawn from deep wells in the earth, so much as to draw upon the water-supply of the river Coln, which like that of all rivers is more or less dependent upon surface influences in addition to overflowing springs. Wells to supply London, the Professor thinks, must not be utilized to draw water from a depth of thirty or forty feet because it would cut off the supply due to the rains which do not sink deeper than three feet! It should have been the easiest possible thing to supply London without in any way drawing upon the supply of the river Coln, since the river and the wells draw from different sources. The learned Professor had no idea of the existence of any force in the premises other than hydrostatic pressure, and yet he proceeds in the next paragraph to give important evidence of some other force:

"In Germany, Mr. Buckmann, of Heilbronn, published in 1835 an octavo volume on artesian wells in the valley of the Necker, from which it appeared that there were manufactures in Wurtemberg near Constadt where the mills were kept in work during the severest cold of winter by means of the warm water from artesian wells which overflowed into the mill-ponds and prevented them from freezing. And at Heilbronn, also, there were persons who saved the expense of fuel by conducting artesian warm water in pipes through their houses and greenhouses. . . . Let those who doubt go to Grenelle and see the majestic column of warm water from the philosophically discovered fountain rising thirty feet above the surface, at the exact temperature foretold by Arago, and learn the correctness and value of practical deductions from geology applied to the useful purposes of life."

From which quotations it appears that the Professor is in a remarkable position. At Wetford these wells could not be utilized because the river-supply of the Coln would be exhausted; but in Germany they were a new and important source of supply to the rivers themselves. Imagine the "majestic column" at Grenelle rising thirty feet high and the overflow in the other cases being due to hydrostatic pressure—i. e., due to the fact that all these immense floods were the result of a flow from some other higher bodies of water. Why did it not occur to Professor Buckland that, however high and abundant the source, such drains must of necessity have sooner or later exhausted the supply, if no equivalent streams were flowing into that also? But suppose this to be so, whence could come the higher head to flow into and supply that in turn? Carry this on until a flow is secured from the high-

est land on the earth, and then whence comes the flow to supply that? The mere statement of the case proves the existence of some force in nature other than hydrostatic pressure by which these vast bodies of water are driven to the surface. This hydrostatic pressure Professor Buckland thus illustrates and explains: "The portions of a water-logged, porous bed between two beds of clay may be illustrated by a tea-saucer placed within another tea-saucer, and having the narrow space between filled with sand and water. If a hole were drilled through the bottom of the upper saucer and a quill or small pipe fixed vertically in the hole, water would rise in the pipe to the level at which it stands within the margin of the lower saucer, its rise being caused by the same hydrostatic pressure that raised the water in the well at Southampton, coming from subterranean sheets of the fluid which exists in the fissured chalk-beds of the Hampshire basin, as they do also in the chalk under the basin of London."

Should these exceptional and assumed conditions occur in nature, the result would be substantially as indicated; but, as will be seen at a glance, the flow from a well sunk under such circumstances would be limited to the amount of water between the two saucers, and this will be limited to the quantity of rainfall. Since flowing wells and springs are seldom if ever thus limited, we infer that the case supposed does not occur. But whether it does or not is of no importance, since it in no sense satisfies the conditions of the "majestic column" at Grenelle, and other cases where the flow is perpetual. We must, therefore, look for some other force to explain this class of phenomena. Professor Faraday followed Professor Buckland's lead six years later. M. Garnier, the celebrated French engineer, whose essay in 1822 upon this subject took the governmental prize, also takes this position; as does Dr. Halley. This theory we combat not merely from speculative motives, but in the interest of public health.

Various other theories have been advanced besides hydrostatic pressure. Aristotle and Seneca suggested the central heat of the earth. This theory has been more fully and scientifically stated by E. S. Chapin, in his work on gravity. But this is not the force that we seek. It is inadequate, as the following simple experiment shows: If a moderately flowing spring is surrounded by an air-tight inclosure which shall contract, and terminate in a tube, and this tube be allowed to have a discharge some distance below the surface of the water in the spring before its inclosure, it will be found that the water-flow from the spring has been greatly increased, though no change of temperature has occurred. Again, it has been suggested that the overflow of springs was due to capillary action; but this can hardly need a serious consideration in view of the amount and character of those overflows.

There are three classes of water to be taken into account in this discussion: 1. The surface waters mainly influenced by rainfalls; 2.

Subterranean waters, seldom if ever influenced by rains; 3. A class of waters coming from both of these sources. This discussion relates mainly to the second class. But what are the facts as to the flow of water in this class? Arago says of the well at Grenelle, 1,800 feet deep, "The water to supply it may have come from 40, 80, or 100 miles." There is a "large and important spring called Pales's Hole which issues permanently in quantities sufficient to run a mill at Otterbourne (England). . . . Springs of fresh water often rise even from fissures at the bottom of the sea, and one near Chittagong was 100 miles distant from the land." "The artesian well at Tours rose with a jet that sustained a cannon." "Chautauqua Lake rests like a jewel in the crown of a high mountain-ridge. The basin is shallow, with not more than 80 feet of water at the deepest points, and an average depth of about 20 feet. The surrounding hills are low, 100 to 150 feet higher than the water. Viewed from the hills near Jamestown, four miles distant, the lake has the appearance of being lifted up above its shores; you seem to be looking up to a 'hanging lake,' and you wonder the whole concern does not fall over into some of the valleys close around it. It is a wonder to the unpracticed observer where the water-supply of Chautauqua Lake comes from. The lake nearly fills its own valley. There is not a live stream emptying into it, save one, and that would run through a six-inch pipe. Of course, it is supported like a weary sleeper by the springs in its bed. These must be innumerable to maintain a body of water 20 miles long and two miles wide. Where the water is shallow you can plainly see these springs bubbling up from the bottom of the lake. Their warmth cuts the ice out in large spots in winter at points where they are most numerous. You see floating in the lake tufts of water-grass, which have been uprooted from the bottom by these under-currents."—("New York Semi-Weekly Tribune," August 2, 1878.)

This lake is on the highest land in the State, west of the Catskill Mountains, and yet it is but a vast overflowing spring from which issues a large mill-stream. To account for this large flow from the top of this elevated region by supposing it to fall from some other higher elevation is absurd, since there is no such higher ground from which it could flow without being exhausted. The whole mountain-region of northern Pennsylvania may be referred to as another good illustration of high springs. At every step the traveler notices abundant streams of the purest water, gushing sometimes from the very tops of mountains, and it is in these thickly clustering springs that the great rivers of that wild labyrinth of high ridges and deep valleys find their abundant sources. Within sight of the main road which crosses the summit dividing the waters of the Alleghany River from those running into the Genesee is to be seen a cluster of abundant streams which unite and cross the highway—a noisy torrent—rejoicing in being among the head-waters of the latter river, and the brightest product of

overflowing springs. No possible head to this overflow could exist; and, in general, this class of springs flowing out of the mountain-tops can not be materially influenced by the rainfall. There is no land above them from which such torrents could flow in such constant abundance. The White and Adirondack Mountains are also full of similar cases.

"Scribner's Monthly" (vol. xi., p. 784) has a very interesting article by Martin A. Howell, Jr., entitled "Is there a Subterranean Outlet to the Upper Lake Region?" While we are sorry to quarrel with Mr. Howell as to his conclusions, we are very happy to accept his facts. He speculates upon the premise that, because "an area of some 400,000 square miles is drained by the tributaries of Lake Winnipeg alone," a certain amount of this accumulation of waters which do not find an exit "toward the Polar Sea and through the Mississippi Valley" may pass by subterranean channels into Lakes Superior and Huron; and he says that "while Lakes Superior and Huron are supplied largely through such subterranean channels on the one hand, they suffer severely through losses by similar channels at some point in their vast expanse." He shows by a map the track of this supposed underground current to be down the valley of the Illinois from Lake Superior to the valley of the Mississippi. The facts he gives tend strongly to support his novel theory of underground flow southward from the lakes, however it may be as to the amount of it. He gives no evidence that it comes from the direction of Lake Winnipeg, but, on the contrary, the balance of his evidence goes to prove that the Northern lakes are nothing more or less than great, overflowing springs. "That there exist channels of communication with some of these lakes," Mr. Howell says, "has long been believed and admitted by many"; and then, having shown that Lake Superior at its surface is 600 feet above the Atlantic and at its bottom 573, and Ontario to be 235 feet above, with the same depth as Superior, he proceeds to make the following significant statement, which is not at all conclusive as to the intercommunication between the lakes, but is unanswerable as proof that these lakes are overflowing springs:

"And that a great subterranean influx into the upper lakes exists there is little doubt, as a comparison of the discharge through the mighty St. Lawrence with the limited supply from the country bordering on the upper lakes clearly demonstrates, leaving the problem to be settled in the mind as to where this volume does come from in its course to the ocean. Again, the discharge through the St. Lawrence is equal to double the volume poured into Ontario through the Niagara, or into Erie through the St. Clair; suggesting that from the shallowness of Lake Erie and the great depth of Superior and Huron a subterranean channel may connect Superior and Huron with Ontario, giving to the latter, through this source, to be discharged by the St. Lawrence, a greater volume than is given through St. Clair. It is also

a well-demonstrated fact that the volume of water escaping from the lakes through the mighty St. Lawrence is far greater than the amount discharged from the upper lakes into Ontario by the proper channels—the St. Clair and Niagara; and it is also well settled that the supply of Lake Erie from St. Clair is about equaled by its discharge through the Niagara; showing that it receives from no subterranean source any perceptible surplus of water. And this is generally attributed to its comparative shallowness as compared to the greater depth of Superior, Huron, and Ontario"—from which it follows that the immense difference between the outflow and the inflow of Ontario is due to its greater depth, thus making it a possible deep spring; and that this applies also to the other deep lakes; and that Superior, Huron, and Ontario, and possibly Michigan, are overflowing springs of subterranean water. The conclusion is therefore inevitable that this great overflow must be accounted for upon some other hypothesis than that of hydraulic pressure, since there is no higher land which could furnish an adequate supply. Indeed, if we suppose all the land on the continent which is higher than Lake Superior to be but shells filled with water, the difference between the outflow and inflow of Ontario would exhaust the supply in a short time. But the subterranean supply is known to be constant, and has always been so. But Mr. Howell supposes this vast surplus in Ontario to come through a subterranean channel, connecting it with Superior. And here, again, we must thank Mr. Howell for his facts. The surface of Superior is, he says, 600 feet above the sea, and Ontario but 235 above. Therefore, the difference of level between the two is 365 feet. If this channel exists as supposed, the surfaces of these lakes would find a common level, instead of a difference of 365 feet!

Mr. Howell, in presenting the proof that there is a great underflow from Superior southward under the valley of the Illinois River, says: "And here on this bank of the old Illinois, opposite the junction of the Fox River, are the celebrated Mineral Springs. . . . These waters are somewhat similar to the waters of Saratoga County, New York," which certainly proves that they do not come from Superior, the waters of which are not of this class. The editor of "Scribner's Monthly" naïvely adds this note: "Whether the Great Lakes are the true reservoirs from which our Northern wells, springs, and subterranean streams receive their constant supply of water, is a question of sufficient interest and significance to merit a thoughtful consideration. The data upon which the advocates of this theory found their conclusions are manifold and forcible, and, though there may be breaks in the line of evidence, the facts as now established would seem to favor the views which the author of this paper now proposes to define and defend." While Mr. Howell presents strong evidence of a possible underflow from Superior southward, he has hardly claimed that the general supply of the "Northern wells, springs, and subterranean streams,"

all comes from the Northern lakes. A hundred facts are at hand which prove the contrary, even in the vicinity of the lakes. Among these are the magnetic wells at Three Rivers and other places in Michigan and other States. Certainly, Chautauqua, in New York, which has been shown to be but a large overflowing spring, does not draw its supply from these lakes, as its surface is many feet above even that of Superior, the highest of the four Northern lakes.

At different times irregular tidal influences have been observed on these lakes, an example of which is given in this news-note printed in the "Springfield Republican," June 26, 1876: "The water in the canal at Sault Ste.-Marie, Michigan, began rising about ten o'clock Friday morning without any apparent cause, and reached a greater height than has been known for many years. Its variation was four feet nine inches in one hour and twenty minutes." All this without apparent cause. Continuous western winds would have been an "apparent cause," but this did not exist. This and other irregular tidal influences on these lakes are in harmony with the supposed internal force for which we seek.

The following is also well authenticated: "Silver Springs, one of Florida's curiosities, is a subterranean river bubbling up into a basin nearly 100 feet deep and an acre in extent, which sends out a stream 60 to 100 feet wide to the Ocklawaha River six miles distant. To this natural inland port run three streams from St. John's, and in the basin the fish and everything on the bottom can be seen through the crystal waters." Here is a case for which no adequate cause recognized by scientists can with certainty account. A singular case occurs on the shore of the Gulf of Mexico, opposite the town of Alvarado. A ridge of sand has formed on the beach by the action of the wind. It is within memory that, before this ridge formation, "a fresh-water spring was known to exist at its northern extremity, which was then but a few feet in height. The spring is there still, though the ridge is twenty feet in height, the water rising to the top of the ridge."

But instances need not be multiplied. The ordinary observer will recall the common fact that the highest land is universally best supplied with flowing springs, and that these overflows can not be accounted for on the supposition of the fall of waters from higher grounds, since such higher grounds do not adequately exist. "The cataract issuing from the Himalayas, or as it is sometimes called Roodroo, is the source of the river Jumna—a rapid and large river; and in fact, many of the largest rivers of the world proceed immediately from mountains and lakes that are formed from cataracts." Thus the Ganges, Nile, Indus, Senegal, Rhine, Rhône, Vistula, Elbe, Loire, Guadiana, Po, Adige, Swale, Tay, Severn, Don, Monongahela, Platte, Missouri, and numerous others have their sources directly in mountains, and many of these "receive no increase from tributary streams, but issue with such astonishing abundance from rocks as to overflow and fertilize the

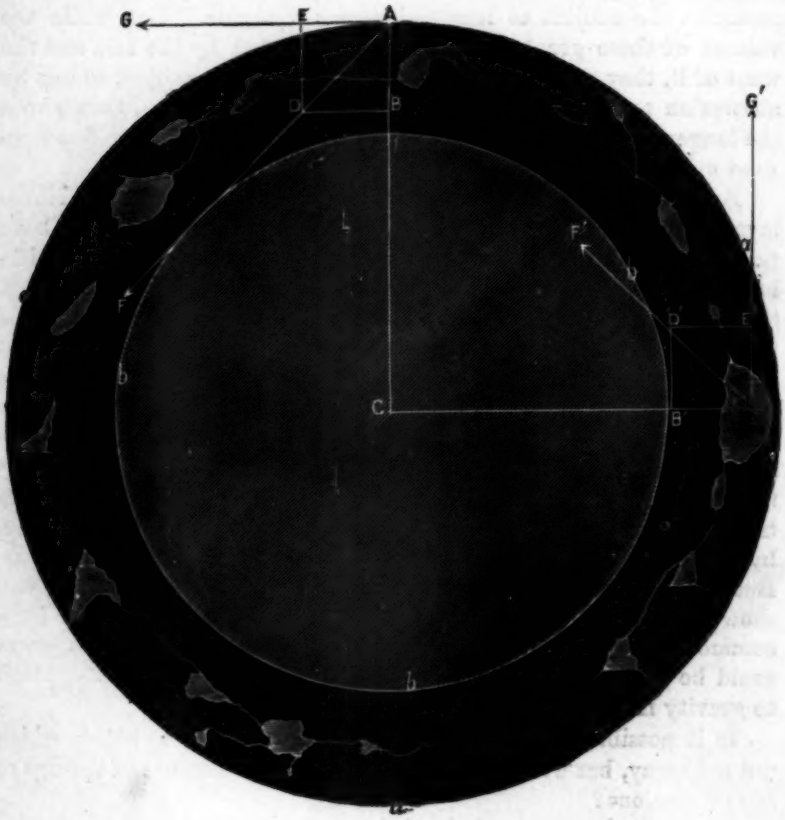
countries through which they pass." This has been more than confirmed by the discoveries of Dr. Livingstone and Mr. Stanley in the heart of Africa, where some of the greatest rivers of the world flow out of the highest part of the African Continent. And in this connection the important element of the rainfall is not ignored. These countries are subject to long and weary droughts. But, while the volume of these great rivers is sensibly affected by the rain and the want of it, they continue to flow within their banks, subject to loss by absorption and evaporation—great and navigable rivers, throughout the longest dry season; and the Nile has no tributaries for five hundred miles of its course.

And, lastly, from the highest mountains in the world—the Himalayas—out of their highest points, great cataracts and streams have poured and still do pour, with an abundance that not only is astonishing, but that would exhaust any possible reservoirs at their extreme tops. Since this is the highest land of the world, no such higher source is possible. Hence the conclusion is inevitable that some force not yet identified exists to which these great overflows are due. It should be remembered that up to this time it is generally held, to use the words of M. Garnier, that "unless there be a reservoir higher than the surface whence we intend to bore, we can not hope to obtain an overflowing fountain." And, as if conscious that there might be some mistake about this theory, he says further that gases may force water up, by which he means to suggest a cause other than hydrostatic pressure. But the experiment which may be seen any day at the gas-works will show that gases do force water down when both are inclosed by a common receiver. There is no conceivable situation in which gases could be expected to force subterranean water in a direction opposed to gravity in such quantities as to satisfy the conditions.

Is it possible, then, to point out any other force in nature which not only may, but which positively must, force waters out of springs at high elevations?

Let *a*, *a*, *a*, be a great circle of the earth attained by passing a plane through the earth's center C, perpendicular to its axis, and *b*, *b*, *b*, the circle cut by the same plane through the inner surface of the earth's supposed crust. In order to obtain room in the figure for illustration, this section is exaggerated. Let the line A B represent the force of gravity, and A E the centrifugal force, at the point A, which will operate in the direction of the tangent A G. These two forces, for the purposes of this discussion, may be assumed to be equal, as the question of their relative intensities does not enter into the problem. Erect upon the line A B the square A B D E, and draw the diagonal A D produced to F. By a well-known law we shall have A D representing the resultant of the forces A B and A E—that is, the line A D will represent the direction A F, and the intensity of the resultant of the force of gravity and the centrifugal force, acting at the point A.

It will be observed that since the diagonal either of a square or of a parallelogram is longer than either of its sides, the resultant, A D, will have a greater intensity than gravity represented by A B. Now, suppose the point A′ to be some point inside the earth's crust, and some



distance from the surface, and suppose also that it is a particle of water in a body of water imprisoned by surrounding rocks. This particle will be acted upon by a continual impulse to move in the direction A′ F′, with an intensity represented by A′ D′. This will be true of every other water-particle in the imprisoned body of water.

If, now, in an hermetically sealed vessel of water a set-screw is turned and pressed upon the water inside until the resistance to it is equal to one pound, that one-pound pressure will be duplicated upon every other equal space of the vessel: and thus, if the end of the screw has one square inch of surface, every square inch of the inside of the vessel will feel a pressure of one pound. Exactly this will occur in the case of the water imprisoned in the rocks. The resultant of the two natural forces, centripetal and centrifugal, will be duplicated upon

every point of the inside surface of the supposed rock-prison. The intensity of this resultant will be represented by the aggregation of all the resultants of all the particles of water. Now, suppose a small opening to be made in this rock-prison. Immediately, the water will be forced out with a velocity equal to the influence of these aggregated resultants modified by the laws of friction, and this velocity will not be at all influenced by the direction of the original impulses given to the water-particles. Although the direction of the resultant itself is say 45° from the direction of the force of gravity, its transmitted force will be unimpaired should the opening lead in a direction opposed to gravity, or in fact in any direction, since the tendency of water expansion or reaction under pressure is uniform in all directions. Moreover, since the resultant has been shown to be greater under all circumstances than gravity, certainly the vast aggregations must also be greater than the aggregated gravity, and will be able to overcome it under the conditions stated.

Hence, if fissures exist in rocks that lead to imprisoned waters it would happen that through these outlets the waters must certainly flow; and, if by any artificial means, as by boring, an opening should be made between a body of confined water and the surface of the earth, a flowing well would result.

But, of course, it must be understood that this would not happen if the body of water supposed were an isolated one and completely unconnected with other bodies of water through channels and intercommunications known to exist in the various ramifications of the earth's surface. The subterranean water circulation which interpenetrates the crust of the earth is clearly caused by the centripetal and centrifugal forces of nature, reënforced no doubt often by differences in temperature and other minor causes. And it also might and probably does occur that the overflowing of a well or spring is due to the fact that the water flows from a higher to a lower level, but this will be found to be too rare to form a rule.

The intensity of the centrifugal force will increase with the distance from the center of the earth, while gravity will decrease; the resultant will also increase. Thus, we find the strongest and most abundant overflows at the tops of mountains or on high plateaus. But suppose it had been fully proved that a particular overflowing spring was caused by hydrostatic pressure, it would still remain to be accounted for how the water got to that higher point. This can best be done by the force demonstrated, which is always acting upon the partially confined water-beds and water-channels forming the internal water-structure of the earth's crust. The conditions necessary to the realization of the best results are that these water-deposits shall be more or less imprisoned and the outlets comparatively limited. The overflow will be continued and upward until the resultant is overcome by friction. The lengthening of the channel of overflow, as in the

spring at Alvarado, furnishes a corroborating instance of how this law of overflow operates. The spring was originally on the level of the shore until the sand drifted by degrees and formed a ridge twenty feet high, *but the water appeared at the top of the ridge.*

This law can be utilized in increasing the flow of water. As above mentioned, it was found that, by inclosing an overflowing spring tightly and allowing the inclosure to be terminated by a tube with an opening carried to a level below the fountain, the flow was increased because the channel was increased, and the resultant of the natural forces with it.

If an artificial connection be made with a stratum of water or water-bed, as by a tube tightly set in the earth or a series of tubes, and the suction-tube of a pump be attached thereto, we shall have the best conditions for a utilization of this newly discovered force in obtaining water for domestic purposes. The natural channels will thus be continued to the pump, and when this is operated (the air being lifted off) the new force acts as a handmaid in lifting the water. Many experiments fully prove this. As the water-deposits drawn upon are subterranean they are ample for all practical purposes; and, if these facts had been within the knowledge of Professor Buckland and the proposed company to which he has given such prominence, London could have been supplied with pure water without the least occasion for anxiety that the manufactories on the banks of the river Coln would be robbed of their portion.

The force, then, which we have demonstrated may be thus formulated: The resultant of the earth's centripetal and centrifugal forces acts impulsively upon the subterranean water-deposits, and tends to force them into and through the natural channels of the earth's crust.

MARS AND HIS MOONS.

By Professor JOHN LE CONTE,
OF THE UNIVERSITY OF CALIFORNIA.

THERE is no member of the solar system, with the exception of our moon, which can be studied under such favorable circumstances as the planet Mars; for, although Venus, when in inferior conjunction, is nearer to us than Mars in opposition, yet Venus, at this time, turns her darkened hemisphere toward the earth. Moreover, although Mars does not appear so large an object in the telescope as Jupiter, yet he is in reality seen on a much larger scale, not only on account of his much greater proximity to us, but because, being likewise much nearer the sun, his surface is much more brilliantly illuminated, so that a much higher telescopic power can be advantageously

employed. Accordingly, ever since the invention of the telescope, Mars has been a favorite object of observation. The largest and most powerful instruments have been employed to scrutinize this planet, and the varied physical details of its surface have been most carefully mapped by many astronomers.

When, therefore, it was announced two years ago* that the American astronomer, Hall, had discovered two satellites belonging to Mars, we ought not to be surprised at the astonishment with which the news was received by the scientific world. Moreover, there can be no question that for more than two centuries past astronomers have recognized the probability of the existence of satellites to this planet. In fact, analogy would lead us to expect that Mars would be furnished with one or more moons; for, being situated at a greater distance from the sun than the earth, it seems more especially to need such luminaries to cheer its dark nights. Under the influence of these anticipations, the astronomers, who have so carefully studied the physical features of Mars, have doubtless been looking for these satellites. In fact, many of them have contended that the failure to discover them is not by any means a conclusive proof of their non-existence; since, Mars being a very small planet, we might expect his moons to be proportionally small, in which case they might escape detection by the telescope. Thus, for example, the second satellite of Jupiter is only about the forty-second part of the diameter of the planet; and a satellite which would only be the forty-second part of the diameter of Mars would be about one hundred miles in diameter. At the least distance of the earth from Mars a satellite of this dimension would subtend an angle of less than one half of a second; so that, even in the most favorable position of Mars, powerful telescopes might fail to reveal such an object, especially if it do not recede far from the disk of the planet.

Thus, Thomas Dick ("Celestial Scenery," American edition, p. 123, 1838) remarks in relation to this question: "If such a satellite exist, it is highly probable that it will revolve at the nearest possible distance from the planet, in order to afford it the greatest quantity of light; in which case it would never be seen beyond two minutes of a degree from the margin of the planet, and that only in certain favorable positions. If the plane of its orbit lay nearly in a line with our axis of vision, it would frequently be hidden either by the interposition of the body of Mars or by transiting its disk. It is therefore possible, and not at all improbable, that Mars may have a satellite, although it has not yet been discovered. It is no argument for the non-

* It was on the memorable night of the 11th of August, 1877, that Professor Asaph Hall, of the Naval Observatory at Washington, caught the first glimpse of these diminutive companions of Mars. The intervention of unfavorable weather kept him in a state of anxious suspense, and postponed, for a period of five days, the complete verification of his great discovery.

existence of such a body that we have not yet seen it; but it ought to serve as an argument to stimulate us to apply our most powerful instruments to the regions around this planet with more frequency and attention than we have hitherto done, and it is possible that our diligence may be rewarded with the discovery. The long duration of winter in the polar regions of Mars seems to require a moon to cheer them during the long absence of the sun; and, if there be none, the inhabitants of those regions must be in a far more dreary condition than the Laplanders and Greenlanders of our globe."

This state of doubt and uncertainty in relation to the question of the existence of Martial moons afforded legitimate game for the satirical writers of the last century. Thus, Jonathan Swift, in his "Gulliver's Travels," published about 1727, in giving an account of the extraordinary race of abstract philosophers who inhabited the "Floating Island" called Laputa, informs us that "they spend the greater part of their lives in observing the celestial bodies, which they do by the assistance of glasses far excelling ours in goodness; for, although their largest telescopes do not exceed three feet, they magnify much more than those of one hundred with us, and show the stars with greater clearness. This advantage has enabled them to extend their discoveries much farther than our astronomers in Europe; for they have made a catalogue of 10,000 fixed stars, whereas the largest of ours does not contain above one third of that number. They have likewise discovered two lesser stars or satellites, which revolve about Mars; whereof the innermost is distant from the center of the primary planet exactly three of its diameters, and the outermost five; the former revolves in the space of ten hours, and the latter in twenty-one and a half; so that the squares of their periodical times are very near in the same proportion with the cubes of their distances from the center of Mars; which evidently shows them to be governed by the same law of gravitation that influences the other heavenly bodies."

About twenty-five years after Swift wrote the foregoing, that is in 1752, the celebrated Voltaire (apparently in imitation of "Gulliver's Travels") cuttingly ridicules the pretensions of the class of reasoners who found their conclusions upon analogy. In one of his satirical tales, Micromegas, an imaginary inhabitant of Sirius, is supposed to make a voyage of discovery through the solar system in company with a denizen of Saturn; they philosophize as they go. Approaching the planet Mars, Micromegas and his companion plainly descried two moons acting as satellites to that body—moons which have certainly escaped the ken of terrestrial astronomers. "I know perfectly well," continues the author of the tale, "that Father Castel" (an astronomer of the time) "will write, and write sufficiently pleasantly, too, against the existence of these two moons; but I appeal against his decision to logicians, who reason from analogy. These excellent philosophers are perfectly aware how difficult it would be for Mars—a planet so far re-

moved from the sun—to get on with less than two of these satellites." ("Œuvres de Voltaire"—Micromegas, chapter iii.) How completely the recent discovery of the American astronomer has "turned the tables" on the renowned satirist of the last century! The previsions of those "excellent philosophers" who founded their conclusions upon analogical reasoning, although slumbering in the domains of the unproved for more than two centuries, have at last been verified by direct observation.

As the moons of Mars are very small objects, it is only under the most favorable circumstances that they can be seen by the most powerful telescopes. Mars is nearest to us when his opposition occurs, when he is near his perihelion; and the greatest possible proximity to us occurs when Mars is in opposition in perihelion and the earth is in aphelion at the same time. The oppositions of Mars near perihelion occur at intervals of fifteen and seventeen years successively. A very good opposition occurred in 1862, and a great many distinguished astronomers embraced the opportunity of scrutinizing Mars with the aid of excellent instruments. A still more favorable opportunity was presented in the summer of 1877, when Mars was nearer to us than it has been since 1845. It was at this time that Professor Asaph Hall was fortunate enough, by means of the new 26-inch refractor of the Naval Observatory at Washington, to discover two moons belonging to this planet. It is true that this was probably the first time that so powerful a telescope had ever been directed to the examination of Mars under similar favorable conditions; yet it is a significant fact that, since the announcement of the discovery, the satellites have been detected by means of telescopes of more moderate power. The secret of Professor Hall's discovery seems to have consisted in devising the means of cutting off, from the field of view of the telescope, the glaring light of Mars. In like manner, M. Henry, of the Observatory of Paris, on August 27, 1877, was able to see the satellites when Mars was screened from view. These diminutive moons nestle so closely to the planet that it is difficult to see them in the blaze of light reflected from Mars. Had similar means of screening the planet been employed, it is probable that one or both of these satellites might have been discovered in 1862.

The distance of the inner satellite from the center of the primary is about 2·73 times the radius of Mars; that of the outer one about 6·846 times the same radius. Assuming the diameter of Mars to be about 4,200 miles, these distances become, respectively, 5,733 and 14,376 miles from the center of Mars. The nearest satellite of Jupiter is distant about six times the radius of the primary, and the innermost satellite of Saturn is distant a little more than three times the radius of that planet.*

* The following table exhibits the mean distances of the satellites from the centers of the primaries, expressed in equatorial radii of the latter. ("Nature," December 13, 1877, p. 129.)

	Earth.	Mars.	Jupiter.	Saturn.	Uranus.	Neptune.
1	60·27	2·72	5·70	2·98	7·71	14·55
2	.....	6·82	9·07	3·83	10·75	.....
3	.....	.....	14·46	4·75	17·63	.....
4	.....	.....	25·44	6·08	23·57	.....
5	.....	.....	.....	8·47	.....	.....
6	.....	.....	.....	19·67	.....	.....
7	.....	.....	.....	24·80	.....	.....
8	.....	.....	.....	57·28	.....	.....

Professor Newcomb gives, for the period of revolution of the *inner* satellite around Mars, about 7·65 hours, or 7h. 39m., and 30·25 hours, or 30h. 15m., as that of the *outer* moon. Both of them, like our moon, revolve around the primary from west to east. Mars rotates on its axis from west to east in 24·623 hours, or 24h. 37m. 23s.; this is the duration of the Martial day. We have seen that the period of revolution of the *inner* satellite is *less*, while that of the *outer* is *greater*, than a Martial day. It is evident, therefore, that, as seen from the surface of the planet, the *apparent* motion of the satellites will be in opposite directions, the inner rising in the *west* and setting in the east, the outer (like our moon) rising in the *east* and setting in the west. This anomalous condition of things must have greatly perplexed the primitive astronomers of Mars, and probably led them to the invention of cycles and epicycles to account for these appearances.

It follows that the phenomenon of two moons meeting in mid-heavens will be no unusual occurrence to the observers on the surface of Mars. The *apparent* motion of the fixed stars from east to west, produced by the rotation of the planet upon its axis, is at the rate of 14·62° per hour. The *real* motion of the inner satellite among the stars from west to east is at the rate of about 47·06° per hour, while that of the outer one is at the rate of 11·90° per hour. Hence it follows that the *apparent* motion of the inner satellite from *west* to *east* across the heavens, to an observer on Mars, will be at the rate of about 32·44° per hour, while the *apparent* motion of the outer moon from *east* to *west* will be at the rate of nearly 2·72° per hour.

It likewise follows from the preceding calculations that the time elapsing between two successive meridian passages of the inner satellite will be about 11·09 hours, and the time elapsing between two successive conjunctions of the inner with the outer moon will be about 10·24 hours; consequently two conjunctions will occur in less time than it takes for Mars to rotate on its axis, or than a Martial day. This satellite completes more than *three* orbital revolutions in a Martial day.

As the apparent motion of the *outer* satellite from east to west is at the rate of only about 2·72° per hour, it is obvious that the time elapsing between two successive meridian passages of this moon will be about 132·35 hours; so that there will be no less than twelve con-

junctions with the inner moon in the course of its lunar day. It is likewise evident that the outer satellite will frequently be above the horizon of Mars more than sixty hours, during which period six conjunctions with the inner may occur. Moreover, as the outer moon will go through its cycle of phases in a little more than thirty hours, all of these changes may be accomplished while it is above the horizon of the observer on the surface of Mars.

The apparent diameter of Mars, as seen by an observer on the inner satellite, would be no less than 41·8°, or about seventy-eight and a half times the apparent diameter of the sun as seen from the earth; and from the outer moon the diameter of Mars would subtend an angle of 16·7°, or about 31·3 times the apparent diameter of the sun as seen by us. Of course the apparent *areas* of the disk of Mars, as seen from his two satellites, would be in the ratio of the *squares* of these numbers, that is, the apparent area of the disk of Mars, as seen from his inner moon, would be 6,167, and from the outer 980 times the apparent area of the solar disk, as seen from the earth.

From the innermost satellite of Saturn, the diameter of the primary would subtend an angle of 35·8°; from the nearest satellite of Jupiter, the diameter of that planet would subtend an angle of 18·6°; and from our moon the earth's diameter would subtend an angle of less than 2°.

Astronomers are, as yet, ignorant of the *real* magnitude of the Martial satellites; but, assuming each of them to be one hundred miles in diameter, it is easy to calculate their apparent magnitudes as seen by an observer on Mars.* The *inner* moon being 5,733 miles distant from the *center* of Mars, would, when in the zenith of the observer, be only 3,633 miles distant from the *surface* of the planet. Hence it appears that, when this satellite is seen in the *horizon* of the observer on the surface of Mars, its diameter would subtend an angle of about 60′, or nearly *twice* the apparent diameter which our moon presents to us; but, when it is in the *zenith* of the observer, it would subtend an angle of 94·3′, or more than *three* times the apparent diameter presented by our moon. In other terms, in rising from the western horizon to the zenith, the apparent diameter of this moon would be increased nearly in the ratio of *two* to *three;* and, of course, its *apparent area* would be augmented nearly in the ratio of *four* to *nine.*

* Professor E. C. Pickering, of the Harvard College Observatory, has attempted to determine the real magnitude of the satellites of Mars, by comparing the *intensity of the light* reflected from the primary with that reflected from each of his satellites. He is thus led to estimate the diameter of the *inner* satellite to be about seven miles, and that of the *outer* one to be about six miles! ("Annual Report of the Director of Harvard College Observatory," November, 1877, page 17.) It is very questionable whether estimates, founded on *photometrical comparisons* in which the *relative reflecting powers* of the bodies compared are *unknown*, can inspire the confidence of astronomers in relation to the *accuracy* of the deduced diameters.

The outer satellite would, under like positions, present apparent diameters, respectively, of 24′ and 28′, or considerably *less* than the apparent diameter of our moon. The nearest satellite of Jupiter (having a diameter of 2,310 miles) would, in like positions, present to an observer on the surface of that planet apparent diameters, respectively, of 31′ and 37′.

As we have seen, the inner satellite of Mars completes *three* orbital revolutions in less than a Martial day. "This anomalous fact in the planetary system would seem, at first view, to be utterly inconsistent with the nebular hypothesis." According to this hypothesis, the *orbital*-periods of the satellites should be approximately equal to the rotation-periods of the primary at the epochs when the satellites were thrown off from it. The acceleration of the rotation-period of the primary, in consequence of its subsequent contraction, would necessarily render its time of rotation *less* than the orbital-period of *any* satellite. As far as yet known, the inner satellite of Mars affords the only instance in which the rotation-period of the primary is *greater* than the orbital-period of the secondary.

It must be remembered, however, that if we regard the rings of Saturn as composed of clouds of independently revolving minute satellites, those constituting the innermost portions of the inner ring must revolve in *less time* than the rotation-period of that planet. Under this view, therefore, the case of the inner satellite of Mars is not *unique*.

There are, however, several methods by which the apparently anomalous fact may be accounted for consistently with the nebular hypothesis :

1. In the first place, it has been suggested that Mars may not have obtained his satellites by means of the usual process of moon-formation, but by the appropriation to himself of a couple of the numerous asteroids or planetoids, some of which, in their perihelion excursions, approach comparatively near to Mars in his aphelion positions. Thus, the planetoid called Phocea, when it is at its *least* distance and Mars at his *greatest* distance from the sun, would only be about 11,000,000 miles from each other. It is, therefore, possible that some of the planetoids, moving in orbits of greater eccentricity than any yet discovered, *may*, at some former period, have approached so near Mars as to have become permanently attached to it as satellites.

2. In the second place, it is possible that these Martial moons may have originally revolved in *larger* orbits, and therefore in *longer* periods than at present, but that the retarding influence of a *resisting medium* on such *small masses* might, in the course of myriads of ages, have *contracted* their orbits and consequently *shortened* their orbital-periods. In this connection it must be borne in mind that, according to the nebular hypothesis, Mars must be a vastly *older* planet than the earth ; so that this retardation may have been in progress for an

incalculable number of centuries before the earth became a separate planet.

Until quite recently, it was generally conceded that *two* comets of short period have revealed the existence of a *resisting medium* in the celestial spaces. It is well known that the celebrated Encke inferred the existence of a resisting medium from the fact that the *periodic times* of the comet which bears his name were *progressively diminishing.*

Thus he found the following values of these times:

1786–1795,	periodic time	=	1208·112 days.
1795–1805,	"	=	1207·879 "
1805–1819,	"	=	1207·424 "
1845–1855,	"	=	1205·250 "

In this view he was sustained by Olbers and most contemporary astronomers, although Bessel and some others dissented from it. But Encke continued steadfast in his theory of a resisting medium in space for more than forty years; in fact, up to the period of his death in 1865.

There are two *other* periodical comets which were expected to furnish important evidence on this question. These are Faye's and Winnecke's comets, which have periods of seven and a half and five and a half years respectively. The orbit of the former has been carefully determined by Professor Axel Möller, of Lund, Sweden. At first his calculations indicated that the period of this comet was shortened at each revolution by about seventeen hours; and Encke, in his declining years, thought that this fact was a *complete proof* of his hypothesis of a resisting medium. But, in 1865, Professor Möller revised his calculations, and found that it was possible to harmonize all of the facts *without* the assumption of the resisting medium.

With regard to Winnecke's comet, it seems that, according to the computations of Professor Oppolzer, of Vienna, it is scarcely necessary to call in the assistance of a resisting medium to account for its motions. It thus appears that, up to the present time, Encke's comet stands *alone* in demanding the existence of a resisting medium to explain its motions. Nevertheless, it must be recollected that such investigations involve the computing of complex planetary perturbations, and that, consequently, more accurate data and better mathematical methods may, in the future, place these two comets in the same category, in relation to a resisting medium, as that of Encke.

In the mean time, divers physical considerations press upon us the *inherent probability* of the existence of a resisting medium in the celestial spaces. The connection between our organs of sense and *remote bodies* necessarily implies the existence of some *intervening medium;* and, moreover, to convey a *physical* impression to the organ of sense, this medium must be *material.* Whatever theory of light we

adopt, we are equally driven to the conception of the existence of some form of *matter* in the celestial spaces. The fact that light and heat are propagated from one part of space to another in *time* demands that the medium of communication should possess *inertia*—an *essential* property of *matter*. According to the *wave theory*, the celestial bodies move in an attenuated and subtile *ethereal medium*; according to the *corpuscular theory*, they move in a perpetual *shower of corpuscles* emitted by the sun and stars. In both cases *matter* exists—*inertia* exists—therefore *resistance* must be encountered. The *smallness* of the resistance, however small we choose to suppose it, does not allow us to escape this certainty. There is resistance, and therefore the movements of satellites *cannot escape its influence*. Nevertheless, such *attenuated* and *bulky* masses as *comets* are best adapted to *test* the existence of a *resisting medium*.

3. In the last place, it is possible that Mars may have *originally* rotated on his axis *in five or six hours*, but that the *tidal rotation-retardation* produced by the action of his moons might have brought about its *present* rotation-period. It is evident that the solar tides, on a planet so small and so remote from the sun, must be inappreciable; and, at first sight, the lunar tides produced by such small masses might be supposed to be equally insignificant. But it must be recollected that the tide-generating power of a moon is (other things being equal) *inversely* proportional to the *cube* of its distance; so that *nearness* might more than compensate for *smallness* of mass. To be more specific: In the mathematical language, the tide-generating power is in proportion to the Thus,

$$\frac{\text{Diameter of Primary} \times \text{Mass of Satellite}}{(\text{Distance of Satellite.})^3}$$

for example, let us suppose the diameter of our moon to be twenty times the diameter of the inner satellite of Mars, and both moons to be equally *dense*; then the *mass* of our moon would be 8,000 times that of the Martial satellite. Taking the diameter of the earth as equal to twice the diameter of Mars (and it is not so great), and the distance of our moon from the center of the earth to be forty-one and a half times the distance of the inner satellite from the center of Mars, we then have the tide-generating power of our moon acting on the earth, will be to that of the inner satellite acting on Mars as $\frac{2 \times 8000}{(41\frac{1}{2})^3}$ to 1, or as $\frac{16000}{71473}$ to 1, or as $\frac{1}{4\frac{1}{2}}$ to 1, or as 1 to $4\frac{1}{2}$. Hence, the tide-generating power of this small satellite would, in consequence of its *nearness* to Mars, be about four and a half times as great as the tide-generating power of our moon on the earth.

This view, however, is not free from the most *serious physical difficulties*. For it is evident that the tidal rotation-retardation produced by the moons would be *limited* by the final condition, that the

rotation-period of the primary becomes exactly the *same* as the *orbital-period* of the satellite. When this condition is attained, the tides can no longer retard the rotation-period of the planet. So far, therefore, as the *inner* moon of Mars is concerned, it must long ago have *ceased* to retard the rotation of the primary. For, the orbital-period of this satellite being far *shorter* than the present rotation-period of Mars, its tidal action would tend to *accelerate* instead of *retarding* the time of rotation of the planet. So far as the *outer* moon is concerned, it is evident that its tidal action must tend to *retard* the rotation-period of Mars; but, in consequence of its greater *remoteness*, the magnitude of its influence must be *small* compared with that of the *inner* satellite. It is, therefore, difficult to conceive how the tidal influences of the moons of this planet can explain the anomalous fact that its rotation-period is *longer* than the orbital-period of one of its satellites.

In connection with the idea of the rotation-period of Mars having, at some *former time*, been much *shorter* than it is at present, it may be noticed that the great compression or ellipticity of this planet is totally inconsistent with its observed rotation-period.*

In 1784 Sir William Herschel estimated the ellipticity of Mars at $\frac{1}{10}$. Schröter refused to admit this result; he contended that, if the ellipticity existed, it would not exceed $\frac{1}{30}$. Bessel failed to discover any appreciable ellipticity of Mars, even with the celebrated heliometer of Königsberg. On the other hand, Arago's measurements, executed at the Observatory of Paris, from 1811 down to 1847, all confirm the existence of an ellipticity in this planet of about $\frac{1}{19}$. ("Astronomie Populaire," tome iv., p. 130. Paris, 1867.) More recent observations give somewhat contradictory results. Professor Kaiser, of Leyden, makes the ellipticity $\frac{1}{114}$; Main, of the Radcliffe Observatory, deduced $\frac{1}{39}$ in 1862; and Dawes's measurements give negative results.

To show the discordance of these results with what may be deduced from the theory of gravitation, it must be recollected that the *ellipticity* of a rotating planet depends upon the *ratio* of the *centrifugal force* at its equator to the *force of gravity* at the same place. Thus, to compare the earth and Mars—

Let r and r' = equatorial radii of earth and Mars respectively.
" t " t' = time of rotation " " " " "
" Q " Q' = mass " " " " "
" f " f' = centrifugal force at equator " "
" g " g' = force of gravity " " " " "

* The *oblateness* or *compression* or *ellipticity* of an oblate spheroid is the *difference* of its equatorial and polar radii, divided by its equatorial radius. Thus, if a and b are the equatorial and polar radii respectively, then ellipticity $= \frac{a-b}{a}$.

Then, by dynamical principles, we have—

$$f : f' :: \frac{r}{t^2} : \frac{r'}{t'^2},$$

and

$$g : g' :: \frac{Q}{r^3} : \frac{Q'}{r'^3}$$

Now, for these two planets we have—

$r = 3962{\cdot}8$ miles, and $r' = 2100$ miles.

$t = 86164$ seconds, " $t' = 88643$ seconds.

$Q = \frac{1}{325000}$, and $Q' = \frac{1}{3095000}$ of mass of the sun.

Substituting these numbers in foregoing proportions, and performing the arithmetical operations, and we have—

$$f : f' :: 1 : 0{\cdot}500704, \text{ and}$$

$$g : g' :: 1 : 0{\cdot}376482.$$

Hence we have $\frac{f}{g} : \frac{f'}{g'} :: 1 : \frac{0{\cdot}500704}{0{\cdot}376482}$ or $1 : 1{\cdot}32996$. But, for the earth, $\frac{f}{g} = \frac{1}{289}$; hence we have $\frac{1}{289} : \frac{f'}{g'} :: 1 : 1{\cdot}32996$. Consequently for Mars we have $\frac{f'}{g'} = \frac{1{\cdot}32996}{289} = \frac{1}{217}$. Now, according to the elegant theorem of Newton, if the rotating planets were *homogeneous liquid masses*, their *ellipticities* would be $\frac{5}{4}$ of $\frac{1}{289} = \frac{1}{231}$ for the earth, and $\frac{5}{4}$ of $\frac{1}{217} = \frac{1}{174}$ for Mars. These are the *greatest possible* values of the *ellipticities* for these two planets with their *present* rotation-periods.* In the case of the earth, we know that it is much *smaller;* being about $\frac{1}{300}$ instead of $\frac{1}{231}$. Hence, for Mars also, we should expect an ellipticity *smaller* than $\frac{1}{174}$; whereas, as we have seen, nearly all the measurements indicate a much *greater* ellipticity.

It is evident that a more *rapid rotation* of the planet would *augment* its ellipticity; hence the question naturally suggests itself: Might not this great ellipticity of Mars have been the result of solidification having taken place when his rotation-period was much *shorter* than it is at present? This explanation is not free from serious difficulties. For, if aqueous and aërial agencies were in action after solidification took place, they would have tended to make the shape of the planet conform to its new rotation-period.

* That the values of ellipticity deduced from the assumption of an *homogeneous liquid mass* in the rotating planet must be *maxima* is evident from the consideration that, if the *density augmented* from the surface toward the center of the planet (which must, from the compressibility of matter, be the *real* condition of things), it would render the computed ellipticity *smaller*. The problem of the *theoretical figure* of a rotating planet is greatly *complicated* as soon as we abandon the assumption of *homogeneousness*.

INTELLECTUAL STRAINING IN AUTHORSHIP.

WE hear a good deal of the joylessness of the present generation, and no doubt there is a greater unrest and a greater impatience among those who lead the forward movement of thought than in any former time. And partly, no doubt, this is due to want of trust, want of power to lean on any invisible hand ; partly, too, to a habit closely connected with this want of trust—a habit contracted by men of the greatest intellect, of straining to see or say something new, as if such straining were the only healthy condition of the mind, as if without it one must sink into a sort of death. Carlyle was one of the first to set the example of this straining. His genius, great as it is, may be almost said to have grown out of the taste for abrupt changes of light and shadow, in the flickerings of which he has contrived to set so considerable a tract of life, both domestic and historic. His peculiar dialect itself is a great instrument for startling men, for giving them little shocks or thrills of unexpected impression. Very often, too, he has succeeded, as some great photographers have succeeded, in producing a very powerful impression by deliberately taking his portraits out of focus. Carlyle's influence is in this respect more or less reflected in Ruskin, who has taught the younger generation of Oxford men so much and yet often so grotesquely, who has fostered so much more excitement of mind than is healthy, and who has accustomed them to so much disproportion between the vehemence of what he says and its truth. And, of those of our younger generation who go abroad for tuition, how many prefer Victor Hugo to any home-bred master for this very reason alone—that his genius is so irregular and grotesque, that it combines so much excitement with so much insight, that there is such a piercing glance and so little law ! It is the same in the New World. There are many who believe that Ralph Waldo Emerson is the greatest of living sages. And certainly his career has been calm and sedate enough, and there is real penetration in his glance. But, though he has never thrown much of emotional excitement into his teaching, his philosophy means nothing, if it does not mean that you get a truer view of life by standing on intellectual tiptoe and straining at a universal truth that is not quite within your reach than you do by humbly putting together what you may really be said to understand. There is no greater contrast between intellectual men than there is between the sedate calm of Emerson and the transcendental exultation or anguish of Victor Hugo. But, on a purely intellectual theme, the one reminds us curiously of the other. Here is a preface furnished by Emerson to a series of portraits of the hundred greatest men of the human race, which has just been begun by an enterprising publisher.*

* Messrs. Sampson Low & Co.

How does he try to interest the reader in the images of these hundred greatest figures of history? Why, by writing thus: "The great are our better selves, ourselves with advantages. It is the only platform on which all men can meet. If you deal with a vulgar mind, life is reduced to beggary. He makes me rich, him I call Plutus, who shows me that every man is mine, and every faculty is mine—who does not impoverish me in praising Plato, but contrariwise, is adding assets to my industry." Well, that alone seems to us pure strain to say something new, without much care whether or not it be true. Beethoven's faculty is not mine, whether I like to say so or not—nay, nothing can make it mine; probably nothing can make me even understand it. Great men are not our better selves, they are only something that our better selves very slowly learn to apprehend. But as if that were not overstrained enough, Emerson goes on: "An ethereal sea ebbs and flows, surges and rushes hither and thither, carrying its whole virtue into every creek and inlet which it bathes. To this sea, every human house has a water-front. Every truth is a power. Every idea, from the moment of its emergence, begins to gather material force, after a little while makes itself known. It works first on thoughts, then on things; makes feet, and afterward shoes; first hands, then gloves; makes men, and so the age and its material soon after. The history of the world is nothing but a procession of clothed ideas. As certainly as water falls in rain on the tops of mountains, and runs down into valleys, plains, and pits, so does thought fall first in the best minds, and runs down from class to class until it touches the masses, and so makes revolutions."

We have heard that kind of thing from Mr. Emerson now for so many years, that it has almost the charm of an old, old landscape, to find him saying again now what he said in the first volume which Mr. Carlyle introduced to the British public with the unique emphasis of one of his peculiar redundancies of repetition, "The words of such a man, what words he thinks fit to speak, are worth attending to." But no one, we think, who puzzled out Mr. Emerson in his youth, and has since compared his mode of presenting the Pantheistic idea with that of other thinkers, will regard it as a simple or natural mode—quite apart from any opinion as to the truth or falsehood of the idea itself. It is emphatically an unnatural and paradoxical mode of presenting it. It is the mode of a man who wishes to say something grander than any clear thought he can express, something that does not fit the thought so much as attract attention to it by phraseological unsuitability and extravagance. It is the style of one of the *Illuminati*, not of simple, sincere philosophy.

And even among a very different school—the school of what we may call physical skepticism, as distinguished from transcendental skepticism—there is the same tendency to intellectual strain, as in the case of the late Professor Clifford—a man of whom his biographer

tells us that, before taking his degree at Cambridge, and for some little time afterward, he was "an ardent High Churchman," but who within ten years of that time gravely assured his Sunday audience as follows:

"On the whole, therefore, we seem entitled to conclude that, during such time as we can have evidence of, no intelligence or volition has been concerned in events happening within the range of the solar system, except that of animals living on the planets. The weight of such probabilities is, of course, estimated differently by different people, and these questions are only just beginning to receive the right sort of attention. But it does seem to me that we may expect in time to have negative evidence on this point of the same kind, and the same cogency, as that which forbids us to assume the existence between the earth and Venus of a planet as large as either of them."

It is hardly possible to regard a statement of that kind, made by a brilliant young man to a popular audience, within a few years of the time when he was himself an ardent Christian, and on the mere strength of the assumption that "mind without brain is a contradiction," except as the result of a delight in intellectual straining for its own sake. It is not merely that the atheistic drift is intrinsically so audacious and violent, but that the mode of its statement is still more audacious and violent. To assert that a disproof of a divine intelligence might be expected of the same degree of validity as the disproof of the existence of a large inferior planet, in a position in which its influence would long ago have been detected, both directly and indirectly—where, indeed, it would have vitiated every calculation made for a century and a half at least—can hardly have been the result of anything but a sheer desire to inflict a great intellectual shock, to produce the excitement of a new intellectual strain. It was, indeed, the product of the same state of mind which made the same brilliant paradox-monger enjoy saying, when at college, "There is one thing in the world more wicked than the desire to command, and that is the will to obey." But that startling saying was commonplace itself compared with those statements which he made as a mature man many years later, to a large and indiscriminate popular audience. And, in his great philippic against the sin of credulity, he strains matters often to a point as shrill. Nay, even Mr. Pollock, in writing his memoir of his friend, appears anxious to strike a similar chord. Speaking of Clifford's last days, he says: "Far be it from me, as it was far from him, to grudge to any man or woman the hope or comfort that may be found in sincere expectation of a better life to come. But let this be set down and remembered, plainly and openly, for the instruction and rebuke of those who fancy that these dogmas have a monopoly of happiness, and will not face the fact that there are true men, ay, and women, to whom the dignity of manhood and the fellowship of this life, undazzled by the magic of any revelation, unholpen of any promises

holding out aught as higher or more enduring than the fountain of human love and the fulfillment of human duties, are sufficient to bear the weight of both life and death. Here was a man who utterly dismissed from his thoughts, as being unprofitable, or worse, all speculations on a future or unseen world; a man to whom life was holy and precious, a thing not to be despised, but to be used with joyfulness; a soul full of life and light, ever longing for activity, ever counting what was achieved as not worthy to be reckoned in comparison of what was left to do. And this is the witness of his ending, that as never man loved life more, so never man feared death less. He fulfilled well and truly that great saying of Spinoza, often in his mind and on his lips, '*Homo liber de nulla re minus quam de morte cogitat.*'"

There is surely a clear straining after startling announcements in the very manner of this passage. Why does Mr. Pollock fall into the manner of our translators of Scripture, with his "unholpen of," and the unmeaning adjective which, from his point of view, he chooses for Professor Clifford's view of life, namely, "holy," unless he wants to emphasize, by the use of such affectations, the antithesis between his meaning and the meaning of the book of which his turns of phrase remind us? And, however true it may be, as it doubtless was, that Professor Clifford met death with the courage and calmness that befit a man in meeting the inevitable, it is clearly nothing but an exaggeration, and an attempt to strain beyond the truth, to endeavor to make us believe that, if, as we are told, Professor Clifford was a man of warm affections, he did not fear death any the more, believing it, as he did, to be the extinction of love, than he would have done if he had thought it but the entrance on a life of deeper and truer love. What Spinoza says is well said for a man of action and for a man of thought, but very ill said, indeed, for a man of loving nature. Thought and action are so full of the present that they do not live in the future. True affection can not but shiver at the thought of extinction, and with Professor Clifford, too, doubtless it was so, as it would be with any one else. It does not follow that, because a man is brave and reticent, he does not suffer from the pang he conceals. If it could be shown that in relation to his personal affections he really feared death less than those who do not regard it as the end of either life or love, all we can say is that the only proper inference would be that he feared it less, because to him it signified less, because he loved less. And that is not at all the inference we should draw from the facts of his life. We suspect that Mr. Pollock is only imitating his friend in straining after a startling saying, without considering that what is intellectually startling is not, on that account, the more, but the less likely to be true.

This tendency to strain after intellectual excitements and surprises, which has flowed from so many quarters upon the present generation, is a very natural accompaniment of an age of discovery and of popu-

lar education—an age when people have been taught to expect constantly new advances, and, in a rough kind of way, even to approciate the enjoyment of an intellectual change of air. But though this love of change may be appropriate to a state of progress, we must remember, after all, that it is most inappropriate to a state of knowledge. The condition of the highest knowledge is the condition of least surprise. The more we have that is real to lean upon the less excuse there will be for this straining and craning of the neck after startling intellectual novelties. Even now we are sure that the tendency to grasp at new ideas is often fatal, not merely to the utilization of old truths, but to the mere holding of the ground which had been gained by our ancestors. All this razing to the earth of the moral and religious beliefs of former days is far more loss to man than the best of the new glimpses of truth are gain. And, indeed, the tendency is to eradicate the temper of repose, the heart of confidence in what has been gained, and to substitute for it a constant reliance on the stimulus of an intellectual excitement the very essence of which depends on change. Professor Clifford begins one of his lectures by pointing out that if any one will consider what he has done during that day, that which he has done oftenest is to change his mind—i. e., not to alter his resolves, but to change the subject-matter of thought and resolve. It is very true, but the tendency of Professor Clifford's and his clique's teaching is to something much more dangerous—to make change of mind an object of aspiration, and almost of moral duty; to depreciate the value of the leaning disposition which rests on what is old, and to overrate that of the mercurial disposition which cares only for what is novel.—*Spectator.*

RESPECTING RUBBISH.

MOST of the substance we call the rubbish of our houses finds its way sooner or later into the dust-bin, and thence into the dustman's cart, which conveys it to the dust-contractor's yard; and there we are for the most part contented to lose sight of it. It is worthless to us, and we are thankful to be rid of it, and think no more of it. But no sooner does it reach its destination in the yard than our rubbish becomes a valuable commodity. The largest cinders are bought by laundresses and braziers, the smaller by brickmakers. The broken crockery is matched and mended by the poor women who sort the heaps, that which is quite past repair being sold with the oyster-shells to make roads; and the very cats are skinned, before their dead bodies are sent away with other animal and vegetable refuse to be used as manure for fertilizing our fields. Nothing is useless or worthless in the contractor's eyes; for rubbish, like dirt, is simply "matter out of place."

The term is an entirely correlative one; what is rubbish to one person under certain circumstances being under altered conditions extremely valuable to another. Gold itself is rubbish in the eyes of a man who is starving on a desert island; and the pearls which adorn a royal diadem, and have made the fortune of the lucky finder, were probably felt to be worse than useless by the poor oyster, tormented by the presence of some particle of matter which he felt to be decidedly "out of place" within his shell. Many a cook, no doubt, has washed the little fresh-water bleak, a fish about four inches long, and had thoughtlessly poured away the water after the operation, before it occurred to the French bead-maker that the lustrous silvery sediment deposited at the bottom of the vessel might be turned to account in the manufacture of artificial pearls, or pearl-beads.

It is, indeed, strange to consider how many of our most highly prized adornments and our most useful and important manufactures are derived from our own and Nature's refuse. The jet which brings in some twenty thousand pounds a year to the town of Whitby alone is merely a compact, highly lustrous, and deep-black variety of lignite a species of coal less ancient in origin than that of the Carboniferous era which we usually burn. And coal itself, as we know, is merely the refuse of ancient forests and jungles, peat-mosses and cypress-swamps, which has been mineralized in the course of ages and stored for our use in the bowels of the earth. Amber, too, which is also used for ornaments, especially in the East, is but the fossil gum or resin of the *Pinites succinifer*, large forests of which seem to have existed in the northeast portion of what is now the bed of the Baltic. To the pine-tree this gum was certainly nothing but refuse, a something to be got rid of; but Nature, who rejects nothing however vile and contemptible, received it into her lumber-room, her universal storehouse, and, after keeping it patiently much more than the traditional seven years, sends it out again, transformed and yet the same, to adorn the Eastern beauty, and to give employment to many a skillful pair of hands. Bogwood, which, like jet, is used for bracelets, brooches, etc., is merely oak or other hard wood which has lain for years in peat-bogs or marshes, and has acquired its dark coloring from the action of oxidized metal upon the tannin it contained.

Turning, however, from Nature's processes to those of man, we find that he is doing his best, however clumsily, to follow the thrifty example she sets him. For many and many a year no doubt the pine-tree shed its pointed, needle-like leaves in the Silesian forests, and there they were left to decay and turn into mold at their leisure, until M. Pannewitz started a manufactory for converting them into forest-wool, which, besides being efficacious in cases of rheumatism when applied in its woolly state, can also be curled, felted, or woven. Mixed with cotton, it has even been used for blankets and wearing apparel. The ethereal oil evolved during the preparation of the wool

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is a useful medical agent, besides being serviceable as lamp-oil and also as a solvent of caoutchouc; and even the refuse, left when the leaves have yielded up their oil and wood, is not looked upon as rubbish, but is compressed into blocks and used for firewood, while the resinous matter it contains produces gas enough for the illumination of the factory.

Truly, as one man's meat is another man's poison, so one man's rubbish is another man's treasure. While the Russians export or simply waste all their bones, other more thrifty people boil them, to extract their grease and gelatine; convert them into charcoal, to be used in refining sugar; pass them on to the turner, to be made into knife-handles and a thousand other useful articles; or grind them up to supply phosphate of lime for the farmer's crops. The commonest and roughest kinds of old glass are now bought up by a certain manufacturer, who melts them up, colors the liquid, by a secret process of his own invention, to any tint he desires, and finally pours it out to cool in flat cakes. These are broken by the hammer into fragments of various size and shape, which are used to produce most effective decorations, such as might be introduced with advantage in many a now plain unattractive-looking building. The cost of this variety of mosaic is less than that of any other, and no doubt it will be extensively used as it becomes better known.

Even such insignificant things as cobwebs are turned to account, not merely for healing cut fingers—Bottom's sole idea as to their use—but for supplying the astronomer with cross-lines for his telescopes. Spiders' threads have even been woven, though one can not imagine where or how, except in fairy-land, by fairy fingers, and for fairy garments; and among the curiosities which travelers bring home from the Tyrol are pictures painted upon cobwebs, the drawing of which is perfectly clear and distinct, with the spider's handiwork at the same time plainly apparent. High prices are charged for these strange works of art, and no wonder, for the cobweb paper—which resembles a fluffy semi-transparent gauze—looks as if it must be extremely unpleasant to draw upon; and no doubt the eccentric artist fails many times before he succeeds in producing a salable article. But we may descend even lower than cobwebs in the scale of refuse, and still find that we have not reached the dead-level at which things become utterly worthless and good for nothing. Nay, much that is sweetest and associated in our minds with luxury and refinement may now be produced from that which is in itself most repulsive; for, while artificial vanilla can be made from the sap of the pine-tree, essence of almonds from benzine, and the delicate perfumes of woodruff and melilot from coal-tar, other scents as fragrant can be obtained from the unsavory refuse of the stable.

Perhaps there is nothing more interesting and instructive, as showing how the meaning of the word "rubbish" varies, than the history

of gas-making. To begin with: the coal which yields most gas is what is termed "cannel" coal, and is now worth from twenty-five to thirty shillings a ton or more; whereas fifty years ago, before the introduction of gas, it was looked upon as almost worthless. In distilling coal for gas, a liquor is produced which for a long time was so great an inconvenience to the gas companies that they actually paid for permission to drain it into the common sewers, as the the simplest way of getting rid of it. This gas-liquor contains salts of ammonia, together with naphtha and tar; and the tar is now made by repeated distillation to yield pitch, benzole, creosote, carbolic acid, the substance known as paraffine, and aniline. It seems strange now that these valuable products should ever have been thrown away as useless; still stranger is it to learn that we derive from one of these waste substances the whole series of beautiful colors called aniline dyes. Naphthaline is another residuary product, by a novel application of which it is said that the light-giving properties of gas may be enhanced fourfold, at a very trifling cost. But the uses to which the waste liquor of the gas-works may be put are not yet exhausted; for not only is it turned to account itself, but combined with the slaty shales found among the coal, which were also at one time a source of perpetual annoyance, it yields alum—used in the manufacture of paper and preparation of leather; copperas or green vitriol (sulphate of iron), used in dyeing, tanning, and the manufacture of ink and Prussian blue; and sulphuric acid.

Rags are now recognized as such a valuable commodity that in some countries their export is forbidden by government; nevertheless, from one source or another the paper-makers of England alone import annually some eighteen or twenty thousand tons of linen and cotton rags, and collect large quantities at home. These rags are of very varying degrees of cleanliness, as may be imagined; some of the English ones require no bleaching at all, while those of Italy bear away the palm for dirt. Old sails are made into the paper used for bank-notes, so it is said, and old ropes reappear as brown paper; but many other things besides flax, hemp, and cotton are now used in the manufacture, and paper is made and remade over and over again. Not a scrap of paper need be wasted, for there are plenty of persons ready to buy it; and, if not good enough for remanufacture as paper, it can always be converted into papier-mâché, no matter what its color or quality. Cuttings of paper severed by bookbinders, pasteboard-makers, envelope-cutters, pocket-book-makers, and paper-hangers are readily bought up; and so too are tons-weight of old ledgers and account-books by the papier-mâché manufacturer, together with old letters and any other paper-rubbish, giving a pledge that all shall be promptly consigned to destruction in his large vat; and out of this heterogeneous assemblage he produces a substance so hard and firm and durable that it has been suggested as suitable for making soldiers' huts and even ships. It is already put to a variety of uses, and is employed

for ceiling ornaments, cornices, frames, mill-board, bulk-heads, cabin-partitions, piano-cases, chairs, tables, etc. One complete suit of papier-mâché furniture inlaid with mother-of-pearl was made a few years ago for the Queen of Spain. Woolen rags are always salable for the purpose of being ground to powder, colored, and used for flock-papers and artificial flowers; while they may be remanufactured, no matter how old they may be, and, with a certain admixture of new wool, converted into a coarse kind of cloth largely exported to South America.

We might go on in this way almost *ad infinitum*, showing how one waste substance after another has been taken up and made into an important factor in the social economy; but enough has been said to prove that it is not so easy as it might seem at first sight to say with any certainty what is rubbish. Of this we may be sure—the wiser men grow and the more they learn of Nature's secrets, the less they will throw away as useless. After all, Nature is the great alchemist; and though necessity is sharpening our wits and making us very clever at turning to account many a thing which our forefathers contentedly threw away, still our best efforts look clumsy by the side of hers, and our dust-yards and lumber-rooms are but repulsive, untidy receptacles compared with her wonderful laboratory.—*Chambers's Journal.*

A REPLY TO "FALLACIES OF EVOLUTION."

By GEORGE J. ROMANES.

I PROPOSE to write a short reply to an essay entitled "The Fallacies of Evolution," which was published in the July number of the "Edinburgh Review." This essay aims at nothing less than stemming of the whole tide of modern philosophy by the material supplied in some thirty diffusely written pages. It aspires to show that the whole theory of evolution is a monster-birth of irrational minds, and, as may be anticipated from such an estimate of this theory, the essay is written by a man comically ignorant of the subject which he presumes to expound.

Lest it should be thought that I am overstating the aim and intended scope of the essay in question, I shall begin by presenting them in the writer's own words: "We must refer our readers, if they desire to master the anatomical details of the problem, to these works themselves. It is not our intention critically to review them. We desire rather to point out, on broader philosophical grounds, how very slight and insufficient the basis is on which so vast a superstructure has been reared, and by what a strange perversion and misuse of the reasoning faculties man is called upon to abdicate whatever most distinguishes him from the brutes."

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Such is the essayist's introduction; and that he deems his ambitious project to have been triumphantly accomplished is evident from the words of his conclusion: "But it is unnecessary to pursue this point any further. We have already said enough to satisfy our present object, which is simply to expose the weakness of the reasoning (if reasoning it could be called) by which the theory before us is assumed to be maintained. The question is essentially one to be decided by the exercise of the judicial faculties, . . . and if so dealt with, apart from all fanciful speculation, we feel no hesitation in asserting that the conclusion will be that at which we ourselves have long since arrived, viz., that development by evolution is merely a rhetorical expression, a form of words, and nothing more."

It will thus be seen that the reviewer's purpose is sufficiently sweeping; and, considering he is not blind to the fact that the weight of competent authority is against him (p. 225), we must at least be startled by the boldness of the man who, without any armor of fact either on the right hand or on the left, rushes like David full of self-confidence against the Goliath of modern thought. The stone which is hurled is indeed in one respect a stone of tremendous weight, the style of the article being ponderous to a degree that borders on pomposity. But, unfortunately, if there is a hole in the armor of the giant, the stone has certainly failed to hit it; and, as the modern champion of Israel has evidently found the armor of fact too heavy to put on, he must not now object to receiving some rough treatment at the hands of the foe which he had the courage to attack.

The allusion to the writer's evident ignorance of science leads me to say at the outset that it is not my intention to waste time by troubling him upon this subject. He expressly says in the passage already quoted that he does not intend to contemplate matters of scientific fact, but to discuss the whole question of evolution "on broader philosophical grounds." It is impossible not to recognize the wisdom of this resolve. When a man supposes that elemental matter is now affirmed to be only one substantial form, at present subsisting in the condition of a gas (the hydrogen—p. 221), or that it is the rule "in the case of ophidian reptiles, serpents, etc.," that "the places assignable to the arms and legs in other animals are occupied by rudimental representatives of those organs imbedded in the surrounding tissues" (p. 228); that paleontology reveals only "a solitary case of approximation to the equine species"; that the sum total of animal species amounts to only one hundred and twenty thousand; and so on—a man, I say, who supposes such things, is no doubt wise to abstain from "critically reviewing" scientific facts. I shall proceed to show that he would have been still wiser had he also abstained from trespassing "on the broader philosophical grounds" of scientific theory.

Taking the features of his article *seriatim*, we may first observe that in his opening paragraphs he displays an altogether erroneous

estimate of what is meant by the faculty of scientific observation. He makes a broad distinction between the "faculties of *observation* and of *ratiocination* or *reasoning*," and states that "they are, in fact, the distinctive characteristics of two different classes of men, regarded with reference to their intellectual endowments. The man of observation, prone to notice and apt to discern the peculiarities of form and substance—all, in short, that comes within the cognizance of the senses—is by no means equally apt to discern, or competent to appreciate, the conclusions to which they are calculated to conduce; while, on the other hand, the man of reasoning, accustomed to deal with the suggestions of the mind rather than of the senses, prone to speculation rather than to experiment, is comparatively unfitted for the more matter-of-fact employment of investigation and research. Both classes of minds and of men are equally essential to the progress of scientific discovery, though it can not be said that both stand on the same level in the estimation of their respective faculties. The faculty of observation, important as it is, is a faculty common, not merely to all men, but more or less to all animated beings, whereas the faculty of reasoning, at least in its higher grades, is peculiar to man alone."

Now, that there is a distinction to be drawn between an observant and a contemplative mind—between a man who sees and a man who thinks—there can be no question. But, that the distinction is of the kind here drawn, no one in the least degree acquainted with experimental research could for a moment suppose. The idea of the writer seems to be that all scientific observation consists merely in a refined use of the senses, the things to be observed lying in Nature already formed, like shells upon the beach. Such an idea is applicable only to the pursuits of a species-hunter, or "systematist"—a man who holds merely the rank of a private in the scientific army. For the discovery of all that deserves the name of scientific truth, for the classifying of hidden analogies and the unveiling of general principles, the highest faculties of the human mind, in the highest degree of their development, must be taxed to the highest degree of their power. With a clear perception of the problem to be solved, a man of science must either think out the particular conjunction of conditions occurring in Nature, which, if found to occur, would give an unequivocal solution, or he must devise such an artificial conjunction of conditions as may lead to the same result. And whether, as in astronomy and geology, the former method be employed, or the latter method be employed, as in all the experimental sciences it must be, I fearlessly affirm that in no department of intellectual activity is there a greater demand made upon that particular faculty of mind which our author terms the faculty of ratiocination. If we follow the intellectual operations by which any of the greater results in science have been achieved, their most conspicuous feature will always be found to consist in the number, the length, and the intricacy of the chains of reasoning converging now

upon this point and now upon that, as each is made the securely-fastened point of attachment for the next. The great distinction between the reasonings, say of the metaphysician and the man of science, consists, not in any difference of degree, but in a difference of subject-matter. For, while the man whom our author calls the "man of reasoning" has no other test by which to estimate the accuracy of his conclusions than the subjective processes of reason itself, "the man of observation" has the uncompromising court of objective fact whither to bring his conclusions for a trial that is sure to be remorseless, and for a judgment from which there can be no appeal. And because the court of Nature is alone infallible, the man of science shows his wisdom as a seeker of truth by directing his best faculties of thought toward the arguing of his case in such a way that the judgment of this court upon the issue presented shall be final. The issue is that concerning the truth of a laboriously reasoned hypothesis; the argument is a perhaps no less laboriously reasoned experiment; and the judgment is either a triumphant verification or a crushing non-suit with costs—the latter being now happily to some extent defrayed by government. In a word, to disparage those faculties of mind which elaborate scientific generalization, as contrasted with those which elaborate philosophic speculation, is surely too preposterously absurd to be entertained even by the most benighted reader of the "Edinburgh" or any other Review.

The author of this attempt appears, from the authoritative style in which he writes, to regard himself as among the favored "men of reasoning, prone to speculation rather than to experiment." That he would be "comparatively unfitted for the more matter-of-fact employment of investigation and research," we can not entertain the shadow of a doubt, and therefore I see no reason why we should hesitate to place him in the category of those who are "accustomed to deal with the suggestions of the mind," without condescending to bring these suggestions to the test of fact. If so, I grieve to observe that in this case the suggestions of the mind have certainly been of a most unfortunate character.

He first briefly considers the present balance of authority regarding the question of spontaneous generation, or the development of living from non-living matter. On this subject I have no remark to make, except that, so far as the doctrine of evolution is concerned, there is no *a priori* reason to anticipate the occurrence of spontaneous generation within the limits of time that are possible to human observation. Miserably small as is our knowledge of protoplasm, we at least know enough to be astounded at its enormously complex chemical constitution, and the no less enormously complex physical properties with which it is endowed. The numerous species of elaborately sculptured shells which owe their varied and intricate forms to the vital activities of protoplasm; the fact that all cells, and therefore all

organizations, ultimately owe their forms and their functions to the apparently same material; and, lastly, the fact that all specific organisms spring from minute specks of this substance, which specks therefore contain and transmit the vital record of billions on billions of hereditary qualities, specific and individual—these things show that the term protoplasm must be considered as merely a general term for all living matter, the constitution of which may perhaps in some cases be comparatively simple, while in others it must be immensely complex, the only common feature of protoplasmic material being that its constitution is too minute for the microscope to analyze. But even if we suppose that the constitution of the simplest form of existing protoplasm—whatever that may be—is as simple as we choose to suppose, it must at least be enormously complex as compared with any known form of non-living matter. Therefore an evolutionist, or a man who believes in the doctrine of gradual development in nature, is certainly not the man who would be prepared *a priori* to expect the spontaneous production of protoplasm within any period that it is competent for experiment to span. If experiment should ever succeed in unequivocally producing protoplasm by artificial means, the fact would, of course, be an immense gain to science, and by bridging the chasm between the physical and the vital would be also a gain to the doctrine of development. But the absence of any such experimental proof of continuity is no presumption against that doctrine, so long as the presumption remains that if the passage from the non-living to the living ever took place it must have taken place by slow degrees.

Passing over the reviewer's comments on the theories of Lamarck and the author of the "Vestiges," I shall at once proceed to examine the main portion of his review, which is simply an attempt at a criticism of Mr. Darwin's work. Here he says: "With the facts, our only concern is to understand them, that we may be able to reason from them. Our business is with the conclusions, to test their correctness in accordance with the recognized principles of right reasoning, that error may be eliminated and truth secured." We shall see that it can not well be said whether it is in understanding the facts, or in testing the conclusions, that this writer has shown himself the more deplorably incompetent.

First, he undertakes to expound and to criticise what he properly terms the distinctive "peculiarity" of Darwinism—the doctrine of natural selection. It may well be thought incredible that at the present day an educated man, writing in a respectable review on the subject of Darwinism, and introducing his criticism with all the solemn flourishes of pedantry that I have quoted, should at once proceed to show that he is entirely ignorant of what the doctrine of natural selection is. Yet such is the fact, and the heavy charge of uninstructed arrogance which I thus level at the writer in question is but too easily maintained by the following quotations (pp. 225–227):

This instrumentality was at first supplied in the theory of Dr. Darwin by the "struggle for life," occasioning the disappearance from the scene of the feeblest and the "survival of the fittest" to carry on the race. The notion is a striking one; and with the advocacy of its able author, his charming style, and the interesting illustrations by which it was supported, naturally produced a powerful impression upon the public mind. A little consideration, however, gradually weakened the first effect. It was presently observed that such a description was only properly applicable to a certain class of animals—the *polygamous*, in which one male in the herd or flock assumes possession of all the females; and to that class but imperfectly, making no account of the females, whose influence in determining the condition of the offspring is at least equal to that of the males. . . .

With regard to the two propositions upon which the Darwinian theory essentially depends, we have already alluded to an apparent objection to the first mentioned, the "struggle for life," and which is indeed equally predicable of the other, the principle of "selection in relation to sex"—namely, that it is limited in its application to certain classes of animals, and those neither the most numerous nor the most important. For we confess we can not understand how either of them could be supposed to prevail at all in at least one whole department of animal life—the *aquatic*. Surely there is but scant room for the hypothesis of a "struggle for life," and still less for that of "selection in relation to sex" among fishes! And these, with the other denizens of the deep, constitute more than one half of the animal kingdom. But there is yet another point of view in regard of which both the conditions in question are obviously inadequate to the conclusion that is built upon them—namely, that it is only in the already advanced stages of animal subsistence that they come into operation at all. The "struggle for life" and "selection in relation to sex" could have no scope for exercise among the lower forms of life; many of them without the power of locomotion, incapable of either seeking their food or choosing their mates. And yet these are, in the theory before us, the foundation of the animal superstructure, comprising the earlier stages of that progressive development which by those means is supposed to be accomplished.

From these passages we can only suppose that their writer believes what he states, viz., that Mr. Darwin's theory of natural selection in the struggle for life is limited to natural selection in what Mr. Darwin has called "the law of battle." In all animals that fight among themselves Mr. Darwin supposes that strength, courage, and all other qualities conducive to success in battle, are some of the qualities which in such animals constitute that "fitness" to survive which is laid hold upon by natural selection in the struggle for existence, and perpetuated in advancing degrees by heredity. But to suppose that the struggle for existence is limited to a literal fighting among animals is a misconception so extraordinary that it could scarcely be suspected, were it not so carefully enforced by the writer himself. Why else should he mention only "the *feeblest*" as those individuals which must disappear in the struggle for life? or why else should the process of natural selection be restricted in its operation to such animals as are "polygamous"? And how else can there be any meaning in the statement that "we confess we can not understand how either of them could be

supposed to prevail at all in at least one whole department of animal life—the *aquatic*," or "that the struggle for life could have no scope for exercise among the lower forms of life," etc., etc.? The truth can only be that this writer has either never read Darwin at all, or that he has forgotten the most distinctive principles of which Darwinism consists. For, it would be needless to tell nine persons out of ten who may read this reply, that Darwin is most explicit in assigning a very subordinate place to the function of actual contest in the struggle for existence; he supposes a host of other agencies to be of far more importance in determining the fitness of the survivors—a host, indeed, which it is literally true that no man can number. Doubtless the poetic force of Mr. Darwin's metaphor has ludicrously misled his critic; and, if the latter were to substitute for it some such term as Competition for Life, it is impossible that we could hear anything more even from the "feeblest" unfortunate among the strugglers against evolution, about being unable to understand how the principle could apply to the lower forms of life.

The remarks, then, which I have quoted concerning natural selection clearly prove that that writer has either never read, or has entirely forgotten, the "Origin of Species." His remarks simultaneously quoted concerning sexual selection further prove that he has either never read, or has entirely forgotten, the "Descent of Man." Otherwise it would have been impossible for him to write, with all the added emphasis supplied by a mark of admiration, "Surely there is but scant room for the hypothesis of a 'struggle for life,' and still less for that of 'selection in relation to sex,' among fishes!" A reviewer has a perfect right to differ to any extent he pleases with the writer whom he reviews, provided that he gives some evidence of having read the works of that writer; but a man who, "listening to the suggestions of his own mind," thinks that he is making a strong point by propounding, as a *reductio ad absurdum*, a belief which the author he reviews has brought a large quantity of evidence to support—such a man can only be deemed a foolish adventurer in the province of criticism. Whether or not sexual selection obtains among fish may properly be regarded as an open question, and the supposition that it does may, perhaps, seem to some persons unlikely, even after they have read all that Darwin has to say upon the subject. But any dubiousness of the doctrine itself does not affect the evidence, which is supplied by the *reductio ad absurdum* form, that the reviewer is ignorant that Darwin has seriously advocated the possibility of sexual selection occurring among certain aquatic animals.

Having spoken of the reviewer's ignorance of the "Origin of Species" and the "Descent of Man," I may next allude to his ignorance of the "Variation of Plants and Animals under Domestication." Here, at least, total ignorance of the work he names is the most charitable construction that we can put upon the following passage:

We can not admit that anything deducible from such premises can have any application in the case before us. What we are here concerned to determine is the effect of the operation of the laws of nature in the state of nature; and this can not be affected by anything that could be achieved in a state in which those laws are superseded by *un*-natural restraints. The conditions of existence in a state of domestication, whereinsoever they differ from those in the state of nature, are by their very definition peculiar to the state of which they are predicated, and consequently out of place in an argument that concerns the ages which preceded the advent and dominion of man. Granted the very utmost that is sought to be established by such means, even to the extent of the actual production of a new species—and nothing of this kind is pretended to—it would leave the question of development by evolution (in the abstract) wholly untouched."

Whether or not this passage has been written after a perusal of the "Variation," it displays an inability to appreciate the function of experiment that to most persons will appear, and rightly appear, lamentable. Comment on so astonishing a passage would be useless, for nothing that I could say could throw its condensed absurdity into any stronger relief. As well might it be said that all our study of electricity is useless for the purpose of furthering our knowledge of natural forces, except so far as observations on the subject are confined to the phenomena of lightning.

Next in order we come upon the writer's estimate of the argument from classification:

The validity of this argument [he says] disappears altogether in view of the fact that just the same state of things would be practicable in the case of a creation according to the vulgar hypothesis of an exercise of the divine power. Considering the mass of animal life to be dealt with, amounting, as just observed, to 120,000 different species, it is almost of necessity that they should be formed upon one or more types or models, implying a certain uniformity of character among the members of the same typical construction, which it is not unreasonable to suppose intended to be evidenced in those animals that were apparently least amenable to it, by the otherwise inexplicable indications of imperfectly developed organs.

Disregarding the error that it is not only in such animals that rudimentary organs are present—seeing that, on the contrary, their occurrence is so general that almost every species presents one or more of them—the idea which is conveyed by this passage is one of the wildest attempts at criticism that I have ever encountered. The instances of affinities in the animal and vegetable kingdoms would, if they could be enumerated, run up into the thousand millions, and extend to the most complex and delicate traits of structure that it is possible to imagine. That such a state of things may be due to intelligent design is a sufficiently reasonable hypothesis, and as such may be properly opposed to the hypothesis of hereditary descent. But the supposition that such a state of things can be due to any "necessity"

arising out of "the mass of animal life to be dealt with," is a supposition that could only occur to a mind altogether unacquainted with anatomical science. The marvel always is, not the accidental similarity of organs, due to the exigencies of their performing similar functions, but the adaptation of anatomically homologous organs to the performance of widely different functions. To take only one instance by way of illustration. Where is the "necessity" that no one among the many species of bats should not have the wing formed in any other way than by the highly peculiar and distinctive modification of the hand? Or where is the "necessity" that all the still greater number of species of birds should have their wings formed by another highly peculiar and equally distinctive modification of the arm? Both structures serve equally well for flight; as, indeed, do the wings of insects and did the wings of the pterodactyl. So far, then, as the exigencies arising out of "the mass of animal life to be dealt with" are concerned, there is no reason why these four types of wings should not occur indiscriminately among the four classes of animals in question—and this even if we follow our author in confining the possibilities of creative invention to the anatomical structures of which we are cognizant. This, of course, is but a general refutation. The absurdity of the argument from "necessity" becomes the more apparent the more numerous and more minute the homologies of structure are found to be within the limits of the same type, without ever transgressing on the equally numerous and minute homologies of any other type. But the fact that homologies never thus commingle—that no one of a vast congeries of organs characteristic of one group of organisms ever appears in any other group of organisms—this fact is of such overwhelming force as evidence of genetic descent, that its supposed failure of application in one solitary instance was, as Sir Charles Lyell wisely observed, to his mind the strongest argument against evolution with which he had met. This solitary case of failure had reference to the eye of a mollusk (the cuttle-fish), which was alleged to be anatomically similar to the eye of a true fish. The allegation proved to be wholly false; but, so far as any "necessity" arising from the difficulty of inventing new forms is concerned, there is no reason why the allegation should not have been true.

Our reviewer next treats of the argument from embryology, and in doing so his ideas present that same crudity of cast which gives to his whole essay its grotesque character. He says: "Certainly these remarks are exceedingly curious, and even in a sense imposing. . . . But these resemblances, be they never so close, infer no real connection between the objects thus heterogeneously associated. It is not pretended that the objects compared together are ever entirely alike—that the unborn young of the higher animal is, at any stage of its development, identical with any of the lower animals, but only that some of the features of the one are like the analogous features of the

We can not admit that anything deducible from such premises can have any application in the case before us. What we are here concerned to determine is the effect of the operation of the laws of nature in the state of nature; and this can not be affected by anything that could be achieved in a state in which those laws are superseded by *un*-natural restraints. The conditions of existence in a state of domestication, whereinsoever they differ from those in the state of nature, are by their very definition peculiar to the state of which they are predicated, and consequently out of place in an argument that concerns the ages which preceded the advent and dominion of man. Granted the very utmost that is sought to be established by such means, even to the extent of the actual production of a new species—and nothing of this kind is pretended to—it would leave the question of development by evolution (in the abstract) wholly untouched."

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arising out of "the mass of animal life to be dealt with," is a supposition that could only occur to a mind altogether unacquainted with anatomical science. The marvel always is, not the accidental similarity of organs, due to the exigencies of their performing similar functions, but the adaptation of anatomically homologous organs to the performance of widely different functions. To take only one instance by way of illustration. Where is the "necessity" that no one among the many species of bats should not have the wing formed in any other way than by the highly peculiar and distinctive modification of the hand? Or where is the "necessity" that all the still greater number of species of birds should have their wings formed by another highly peculiar and equally distinctive modification of the arm? Both structures serve equally well for flight; as, indeed, do the wings of insects and did the wings of the pterodactyl. So far, then, as the exigencies arising out of "the mass of animal life to be dealt with" are concerned, there is no reason why these four types of wings should not occur indiscriminately among the four classes of animals in question—and this even if we follow our author in confining the possibilities of creative invention to the anatomical structures of which we are cognizant. This, of course, is but a general refutation. The absurdity of the argument from "necessity" becomes the more apparent the more numerous and more minute the homologies of structure are found to be within the limits of the same type, without ever transgressing on the equally numerous and minute homologies of any other type. But the fact that homologies never thus commingle—that no one of a vast congeries of organs characteristic of one group of organisms ever appears in any other group of organisms—this fact is of such overwhelming force as evidence of genetic descent, that its supposed failure of application in one solitary instance was, as Sir Charles Lyell wisely observed, to his mind the strongest argument against evolution with which he had met. This solitary case of failure had reference to the eye of a mollusk (the cuttle-fish), which was alleged to be anatomically similar to the eye of a true fish. The allegation proved to be wholly false; but, so far as any "necessity" arising from the difficulty of inventing new forms is concerned, there is no reason why the allegation should not have been true.

Our reviewer next treats of the argument from embryology, and in doing so his ideas present that same crudity of cast which gives to his whole essay its grotesque character. He says: "Certainly these remarks are exceedingly curious, and even in a sense imposing. . . . But these resemblances, be they never so close, infer no real connection between the objects thus heterogeneously associated. It is not pretended that the objects compared together are ever entirely alike—that the unborn young of the higher animal is, at any stage of its development, identical with any of the lower animals, but only that some of the features of the one are like the analogous features of the

We can not admit that anything deducible from such premises can have any application in the case before us. What we are here concerned to determine is the effect of the operation of the laws of nature in the state of nature; and this can not be affected by anything that could be achieved in a state in which those laws are superseded by *un*-natural restraints. The conditions of existence in a state of domestication, whereinsoever they differ from those in the state of nature, are by their very definition peculiar to the state of which they are predicated, and consequently out of place in an argument that concerns the ages which preceded the advent and dominion of man. Granted the very utmost that is sought to be established by such means, even to the extent of the actual production of a new species—and nothing of this kind is pretended to—it would leave the question of development by evolution (in the abstract) wholly untouched."

Whether or not this passage has been written after a perusal of the "Variation," it displays an inability to appreciate the function of experiment that to most persons will appear, and rightly appear, lamentable. Comment on so astonishing a passage would be useless, for nothing that I could say could throw its condensed absurdity into any stronger relief. As well might it be said that all our study of electricity is useless for the purpose of furthering our knowledge of natural forces, except so far as observations on the subject are confined to the phenomena of lightning.

Next in order we come upon the writer's estimate of the argument from classification:

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other. . . . That some such resemblance should, in fact, be found to prevail is only what might naturally be expected, considering that each full-grown individual is itself the result of a process of gradual development from a sizeless and shapeless germ, in which development all its organs equally participate," etc. Here, again, we encounter the same argument from "necessity" that has just been considered; and here, again, it is no less preposterous than it was in its previous connection. For to an embryologist nothing could appear more ridiculous than the statement that "in such a case of gradual development it follows, almost as a matter of course, that both the entire animal and all its component members should, in their advance to maturity from a mere *punctum saliens*, exhibit some faint resemblance" to other and allied animals. As a matter of fact, the resemblance is never "faint" but profound, affecting all the structures which constitute the essential framework of the organism. The kind of resemblance on which the reviewer would appear inclined to place most reliance would be a superficial resemblance of specific details. But although even this is supplied by many facts—such as the hair on the unborn child, clothing the body except on the palms of the hands and the soles of the feet, which are also denuded in apes—it is not of so deep a significance to a philosophical mind as are the deeper resemblances of anatomical structure. Hence, even if the unborn young of a higher animal were, "at any stage of its development, identical with any of the lower animals," the fact would not speak so strongly in favor of its derivation from a lower form as does the fact of its passing through a whole series of changes, each stage of which refers, in some point of anatomical significance, to some stage in the existing grade of animal organizations. Actual *identity* is not what the theory of descent with modification would lead us to expect, seeing that, according to this theory, the comparable features usually refer to features that are derived from a common ancestor lower down in a branching stem of descent. In a family tree we may expect the constituent members to inherit in common some peculiarities possessed by their common ancestors, but we do not expect the personal appearance of all the individuals to be identical. Lastly, when we consider the enormous complexity of organisms, the marvel is how the more complicated, in attaining their higher complexity, mimic so closely the anatomical structures of the organisms lower in the scale of complexity. Far from its being "almost a matter of course," it is in the last degree astounding that a vertebrated animal, for instance, should begin its course of development by the same process of yolk-cleavage that occurs in the rest of the animal kingdom, that its first differentiation of body-layers should present the essential anatomical features of the body-layers that characterize the jelly-fish, and so on. In short, when any one at all acquainted with the facts of embryology regards them *en masse*, the last of all notions to enter his mind will be that they

must be as they are "almost as a matter of course." Rather will he be constrained to ask, "How can these things be?" and it is fortunate that there is now a voice of authoritative teaching to answer, "Art thou a master in Israel and knowest not?"

Next we come to the argument from geographical distribution. Here the alleged fallacy of evolution is as follows: "If the environment be taken to be the cause of the specific characters of the animals, similar environments ought to be productive of similar species. But this is very far from being the case." This is, perhaps, as good an instance as we have met of our author's inability to view all the area of an extensive problem. His idea of what constitutes an "environment" is about as adequate as the idea of space that a baby shows when it tries to grasp the moon. The following expresses his idea: "If the environment be taken to be the cause of the diversification of the species, how is it that, where the scope for diversity of environment is apparently the least, the greater is the variety of species? We have before observed that there are about 120,000 species of animals; of these more than one half are aquatic, the inhabitants of seas, lakes, and rivers; to which distinction, combined with temperature, the grounds of diversification seem almost exclusively confined." This is really exquisite—so exquisite that it seems a pity to mar its comicality by a prosaic answer. But, even though I may spoil the joke by explaining it, I must at least explain to the author himself how good a joke he has made.

First, then, besides varying in temperature, the ocean, in its different parts, varies somewhat in depth, in the nature of its bottom, the strength of its currents, the degree of its saltness, and its relations to the land. Next, as contrasted with the land, the water on the globe presents an immensely greater—not only area—but cubical capacity for sustaining life. Again, and of still greater importance, it is a matter of fact, whether or not the doctrine of evolution is true, that geology reveals the existence of multitudinous forms of aquatic life as preceding in time the advent of terrestrial life. And, as the theory of evolution supposes that all the latter forms of life are the lineal descendants of the former, it is clear that by the terms of this theory, no less than by those of geological fact, far more *time* has been allowed for the differentiation of aquatic than for that of terrestrial species. Indeed, looking to the degree in which water, as contrasted with land, has thus been favorably handicapped in the time allowed for the production of species, the only wonder is, that the water does not show a greater comparative wealth of specific forms than it does. But, lastly, and most important of all, it is a huge blunder to imagine that an "environment" consists merely in the physical conditions as to medium, climate, etc., to which an organism is exposed. Of far more importance are the innumerably complex relations of the organism to its neighboring organisms, whether of its own or other species, to

which must be added the effects of hereditary endowment from a long line of ancestors occupying other and changing environments, to all of which these ancestors must have been structurally adapted. The word "environment" is a term of the most comprehensive kind, embodying, in every case that it is used, an assemblage of conditions presenting an amount of complexity that is not only inconceivable but wholly unnamable. It is nothing less than amazing to find a man at this time of day seeking to argue that environments can not "be the cause of the diversifications of species," on such grounds as that different species flourish in "parts of South Africa and Australia which are wonderfully similar in their soil and climate." Indeed, not to prolong the discussion of nonsense, I will conclude this part of my reply by quoting the sentence with which he concludes his statement of this particular "fallacy of evolution." I do so because, while he appears to think that the question is of so unanswerable a character as to deserve the place of anti-climax in his argument, it really presents as good an example as could anywhere be found of misconception blatant. Here it is: "And then, what is to be said for the multitude of species to be found in the same localities, the same forests, the same jungles, the same lakes, the same streamlets, where there is literally no room for any difference in the environments at all?"

After an *exposé* of ignorance so crass I do not think that I should be performing any useful function by following the writer any further in his luckless flounderings. The rest of his article consists in a trite statement of the facts that species are not producible by artificial selection, and that some specific forms have remained unchanged through long geological epochs—neither of which facts has the smallest tendency to negative the doctrine of descent.

He also devotes a page or two to sustain the theory that the lake-dwellers and other prehistoric men were the "degraded descendants of a civilized ancestry." Of course, in so doing he has no facts to adduce—merely maintaining that "it is just as possible, just as likely, that the artificers in stone, and the dwellers in the caves of the earth, were the degraded descendants of a civilized ancestry, as the barbarous ancestors of a civilized posterity"—forgetting, on the one hand, that, *if* the general theory of evolution be true, this is *not* so possible or *not* so likely; and, on the other hand, that it is a very unfortunate fact for the possibility and the likelihood in question that the "civilized ancestry" should have been so much less fortunate in leaving behind them relics of their existence than have been their "barbarous posterity." Next, he treats of "the distinction and equable distribution of the sexes." This is, indeed, a subject which the theory of evolution has not yet been successful in completely explaining; but our author, by again displaying his ignorance of Mr. Darwin's writings, has not made so strong a case as he might have made. He appears to think it self-evident that over such things "the struggle for

life and natural selection must be equally powerless"—a statement which is self-evidently absurd; for, although a man may doubt whether the alleged cause (natural selection) is competent to effect all that Darwinians here suppose, this writer only weakens his own case by showing that he is ignorant of such a cause having been alleged. And no less unfortunate is he when "attending to the suggestions of the mind" in the matter of protective coloring. For, after stating one or two cases of protective coloring, he makes the startling announcement: "Here, then, are examples of the adaptation of the species to the conditions of their existence which can not . . . . be by virtue of any law of nature; for we neither know of any such law, nor can we conceive of any that could produce the effects in question exclusively in the case of the few species alluded to without regard to the multitudes inhabiting the same localities." Here, again, the most charitable supposition we can make is, that the writer has never read the doctrines which he undertakes to criticise. For, if, after having read all the evidence in favor of protective coloring, he could think to dispose of it by so absurd a criticism as this, we must refuse to consign him a place even among those whom he calls "men of reasoning." If three animals—A, B, and C—inhabit the same locality, and if A is protectively colored, while B and C are not, what must we think of the reasoning which from these premises alone definitely concludes that the imitative coloring of A can not conceivably be due to the operation of a natural law? There may be a thousand and one reasons why B and C should not be affected by the law of protective coloring; yet, merely on the ground that all animals in the same locality are not so affected, we are told to conclude that all the thousands of cases in which animals are thus affected constitute no evidence of the operation of a natural law! Did ever our "man of reasoning" hear of a method of reasoning called the method of concomitant variations?

Lastly, the reviewer enlarges upon the absence of paleontological evidence of connecting specific forms; but, as we have already sufficiently gauged his competence to deal with such subjects as the imperfection of the geological record, I will not occupy further space by considering what he says, further than to show by one concluding quotation the truly appalling state of things, which "it can require but little reflection to perceive" would have been the result of organic evolution, had the world been so unfortunate as to have been subject to such a process. "It requires but a very small stretch of thought further to perceive that, so far from such a principle of creation affording reasonable grounds for the inference of the development of the *species*, according to the present intent of the term, the result must have been the absolute exclusion of all *species* whatever—the production of an indiscriminate mass, or rather *mob* of animals, extending in indistinguishable series from one end of the creation to the other."

Here I gladly stop. It is not to be expected that the majority of

those who read the criticism can themselves be in a position to estimate the full extent of its impudence; and for this reason I have taken the trouble to show how, as a criticism, it is beneath contempt —useful only as a warning to those whom it concerns to abstain from meddling with any subject which, neither by mental constitution, thought, nor training, are they in the lowest degree competent to treat.—*Fortnightly Review.*

THE INAUGURATION OF ARAGO'S STATUE.

THE statue to Arago recently unveiled at Perpignan is not the first erected to that great astronomer and greater physicist. In 1867 M. Isaac Pereire, then representative of the native place of Arago in the Imperial Chamber of Deputies, erected one at his own expense at Estagel. The inauguration was accompanied by speeches delivered by the generous donor, M. Bertrand, the Perpetual Secretary of the Academy of Sciences, and others. It was stated then that Arago had supported against his own party the construction of the railways by public companies, and had been grossly abused by some of his political friends. Although a political leader, it must be said, to the glory of Arago, that he never was influenced by party considerations. He was always writing, and speaking, and voting according to the *dictamina* of his own judgment. These facts should be remembered, as efforts have been made, in the recent Arago celebration, to degrade him into a mere politician, which never was the case. Arago was made a member of the Provisional Government of France in February, 1848; it was owing to his personal exertion that the abolition decree was proclaimed before the convocation of the National Assembly. It is true that he was appointed in the beginning of May one of the *quinquemvirs* of the Executive Commission. But this Government was overthrown by the popular rising of the end of June, and from that time he abstained from taking any prominent part in politics.

Arago was not rich, his works having been mostly published in the "Annuaire du Bureau des Longitudes" without any copyright, and sold for the benefit of the Bureau, of which he was the most influential member. His paying works were all of them posthumous, and edited by M. Barras, the Perpetual Secretary of the Agricultural Society of France. The sale was not so large as anticipated, and the publisher who purchased the copyright from the inheritors failed. The sale of the "Annuaire" was so large during Arago's lifetime that the Bureau had a profit by it. Since his death it has become necessary to provide special funds for the publication of that useful work.

Arago had no salary at all as director of the Observatory. He was

appointed every year by the Bureau, receiving only £200 for his membership. His other salaries were £50 as a member of the Academy of Sciences, £250 as Perpetual Secretary, and when he was lecturing on astronomy, £50. The functions of deputy and member of Municipal Council of Paris being entirely gratuitous, he was no receiver of any other public moneys. Under the republic his membership of the Assembly brought him one pound a day.

From the eloquent *éloge* pronounced by M. Paul Bert at the recent inauguration, we take the following extract: "To contemplate Arago under all the aspects that may attract the admiration of posterity we must think of him as a man of science overturning the Newtonian hypothesis of the emission of light, determining the physical constitution of the sun, explaining the scintillation of the stars, the nature of the aurora borealis, discovering magnetization by currents, the origin of the electric telegraph, extending to all bodies magnetic properties; finally, for I must limit myself to the most prominent points, indicating to the most eminent of his disciples the star still unknown and invisible, whose discovery introduced order among the perturbed planets, and which still remains the most extraordinary mark of the power of human genius. As a professor, again, before three thousand auditors at the Observatory, or in his chair as Perpetual Secretary, writing his incomparable scientific notices, or dictating, when blind, his popular astronomy, always, by speech or by pen, marvelous for his clearness, his accuracy, his power and fullness, elevating all he touched, returning to the astonished inventor his discovery developed and fertilized, sowing broadcast his ideas, and rejoicing when others, friends or foes, were enriched by the precious fruits of his genius. As a scientific historian he excelled Condorcet, equaled Cuvier and Fontenelle, and was characterized above all others by his eagerness to give every one his due, and his jealous love of justice. As an orator he carried into the tribune the vigor and clearness of the scientific chair, vivified by the emotions of master-spirits, and dominating the assembly by his lofty stature, with his beautiful southern head, and his eye full of fire. He was a man, in fact, in whom the will to act was united with the consciousness of power, an intelligence marvelously comprehensive and powerfully creative, so bold and yet so prudent at times that it never committed an error that required to be retracted. Of an ardent but loyal nature, ready for power, but incapable of hatred, and thirsting for justice, a heart sensitive and valiant, sometimes drawn, says a contemporary, to show itself severe to the strong in order to support the weak; a soul austere but a brow serene; a father and citizen worthy of the ancient legends, and able, like Carnot, on quitting life to bear the noble witness, 'My hands are clean and my heart pure.' From the extent of the sketch you may judge what will be the nature of the picture."—*Nature.*

SKETCH OF DR. ASA FITCH.

By E. P. THURSTON.

THERE is in the world a class of men whose characters, labors, and attainments well entitle them to be called great, who are yet so modest in their self-estimate, so unassuming in their knowledge, that those who dwell about them recognize only the common characteristics of average men; or if, from peculiar ideas and habits, they are found to be different, the difference is accredited them with complacent tolerance. They are so guileless in life, so pure in thought, and withal so generous-hearted, that in ordinary affairs the world holds them at a disadvantage, quietly appropriating the fruits of their labors with little if any sense of obligation. To this class belonged Dr. Asa Fitch, well known in the scientific world as a distinguished entomologist, whose writings and investigations have contributed largely to our present knowledge of American insects.

Dr. Fitch was the descendant of a long line which in this country, in early colonial times, was linked with the Brewsters of the Mayflower, and other distinguished families. He was the second son of the Hon. Asa Fitch, M. D., a man eminent in the medical profession, and equally so in various positions of public trust to which the people called him.

The subject of our sketch was born at Fitch's Point, Salem, Washington County, New York, February 24, 1809. His childhood was passed on a farm, and until twelve years of age he attended the district school. He was then sent to the academy at the neighboring village of Salem, and at about the same time began a journal of the interesting and important events of his daily life, which, with two or three brief lapses, was continued until his death. Early entries in this record betray the possession in a marked degree, even in his boyhood, of keen observing powers, and a rare faculty for accuracy and lucidity of description, characteristics which in later life grew into striking prominence, and gave to his scientific work an exceptional value. He was an unusually studious pupil, and early evinced a preference for the natural sciences, botany first claiming his attention. In his fifteenth year he began, according to a note in his diary, to arrange the botanical collection of his preceptor in classes and orders. His studies at the academy completed, he remained at home until his eighteenth year, engaged a portion of the time as clerk in a neighboring store.

In the spring of 1826 his father sent him to Rensselaer School, at Troy (now the Rensselaer Polytechnic Institute), where he soon became deeply interested in natural history, zoölogy almost immediately awakening his enthusiasm. The bent of his mind toward en-

tomology quickly declared itself, and it was not long before the insects had more or less complete possession. He graduated with honor at the Rensselaer School with the class of 1827, and immediately after, at the instance of his father, began a course of medical studies, attending lectures at the Vermont Academy of Medicine, at Castleton, but still giving much of his time to the study of insects, the observation of which had now become almost a passion. He persevered, however, in the medical course, graduating M. D. in 1829, and afterward attended lectures at Rutgers Medical College, in New York City, concluding his preparation for the profession in the office of the late Dr. March, of Albany. While thus engaged he made industrious use of the libraries of that city so far as they could aid in advancing his knowledge of entomology. Being unable to purchase the books he needed, and determined to possess all the information they contained about the insects of this country, he copied with great accuracy and rapidity, from the various entomological works in both the State and academy libraries, all that had then been written on American insects.

His medical studies terminated, in the capacity of Assistant Professor of Natural History he accompanied the Rensselaer School Expedition of 1830 to Lake Erie, having then just attained his majority. The President of the school, Professor Eaton, regarded him at this time as the best entomologist in the United States, and he was urged by his friends to publish on the subject. He replied that "Sir Walter Scott was above half right, 'Study in youth, and publish in mature life,'" a precept the youthful investigator followed. At the western terminus of the expedition, Dr. Fitch left the party and traveled extensively in the Western States, collecting and analyzing the rare species of insects found in the localities visited. He returned home in the summer of 1831, and almost immediately began the practice of his profession at Fort Miller, New York, having his office with Dr. Tayler Lewis, afterward the distinguished Professor of Greek in Union College.

November 15, 1832, Dr. Fitch married Elizabeth, daughter of John McNeil, of Stillwater, New York, and soon after removed to that place, continuing the practice of the profession he cordially hated, for six years. In 1838 he gave up practice and returned to Salem, to assume the management of his father's business, for which the latter had become incapacitated by ill health. From this time he devoted himself largely to agricultural pursuits, which gave more ample opportunities for investigation in his favorite field, that he was not slow to improve. It is related that he would frequently be seen after a shower, on his hands and knees, searching about for insects and all manner of "creeping things," and would finally return to the house with his tall old hat completely covered inside and out with the writhing victims of his scientific greed. He was nicknamed "The Bug-Catcher" by his neighbors; and so eager became his quest for curious specimens in

wood, field, and stream, that many thought him demented, while others declared that he destroyed more grain than his scientific investigations were worth.

At its organization he became identified with the Washington County Agricultural Society, and soon began to give attention to the public need by various contributions to the local journals on economic entomology. In 1845 he published in Dr. Emmons's "American Quarterly Journal of Agriculture and Science" an article of thirteen pages on "Insects of the genus Cecidomyia," in which he described a new species of willow gall-fly, illustrating it by figures of the insect in different stages of growth, and of the excrescence it produces on the willow. This was his first formal entomological essay. Six months later he sent another of thirty pages to the same journal on "The Wheat-Midge," and, in 1846, a third of sixty-three pages on "The Hessian Fly." This was afterward revised and republished in the "Transactions of the New York State Agricultural Society." In 1847 he published a valuable paper on "Winter Insects," of which he was the first to write specifically; and also in the "Transactions" gave an account of the currant-worm and its moth. This paper, beautifully illustrated with colored engravings, was widely copied in foreign scientific journals, and brought its author prominently into notice as a scientific investigator. At this period Dr. Fitch was employed for a time collecting and naming the insects of the State of New York, for the State Cabinet of Natural History. In the Report of the Regents of the University for 1851 he gave a descriptive catalogue of the insects of New York of the order *Homoptera*, in which he named and described a number of new species.

In 1854 Dr. Fitch was appointed New York State Entomologist, and held the position seventeen years, during which period he devoted himself exclusively and most assiduously to scientific work. The little office a few yards from his residence became his workshop, and night and day sent forth light to the world. So close was the watch he kept at the hatching-time of the various larvæ collected, that for a week together he would catch his sleep in an arm-chair, waking at intervals to note the wonderful changes taking place in the insect-life before him. At such times, his meals, and an extra hour after tea to read the news, was all the recreation he allowed himself, and even then his pocket-net was always within reach, to capture any unwary moth or curious beetle whose love of light attracted it to the room. Dr. Fitch was a most devout Christian, and reading the Scriptures and prayer with his family was a daily habit of his life. But even when thus engaged it was not safe for an attractive insect to come in his way. A daughter, the one to whom he was indebted for many of the beautiful drawings which illustrate his writings, relates that on one such occasion when he had the Bible in his hands, and was about to begin reading, a moth of peculiar appearance alighted on the book

before him. The ruling passion was too strong for either time or circumstance: glancing about, as if conscious of the incongruity of the proceeding, he quickly seized his net, bagged the curious specimen, and with a half-guilty look proceeded with the reading. The capture was an important one, as the moth proved to be new to science.

While State Entomologist, his correspondence grew so large as to seriously interfere with other work, and he was at last reluctantly compelled to answer only such letters as were of most importance, devoting the remaining time to research and the preparation of his annual reports. These reports, of which there were thirteen in all, were published in the "Transactions of the State Agricultural Society"; the first nine being also issued in three bound volumes, which were widely circulated both here and abroad, and attracted very favorable attention. His researches were thus brought to the knowledge of foreign entomologists, their value promptly recognized, and the Doctor was soon enrolled as corresponding member of several foreign entomological societies, and later became the recipient of their diplomas, medals, and other testimonials of the appreciation in which his work was held.

The great entomologists of Europe—Westwood and Curtis, of London; Dr. Signoret, of Paris; Dr. Gerstacker, of Berlin; Baron d'Osten-Sacken, of St. Petersburg—were quick to avail themselves of his discoveries, not only by gleaning from his published works, but through the avenue of personal correspondence. His portfolios of foreign correspondence are literally filled with letters of inquiry and acknowledgment from such noted specialists as Dr. Sickel, M. Selys de Lonchamp, and the Abbé Marseul, of France; Professor Boheman, of Sweden; M. Malde, of Germany; and Andrew Murray, of Edinburgh, together with many others of equal reputation.

The success Dr. Fitch achieved was not in any sense the result of favoring circumstances, but the legitimate outcome of his patience in observation and study—study which was always directed by a well-defined plan to a definite object, which as early as 1840 he thus laid down:

"I have undertaken a very great work, and have laid upon myself a task both hard in the plan and difficult in the execution. To unite in one very limited body the most essential facts of the history of insects; to class them with precision and accuracy in a natural series; to delineate the chief traits in their physiognomy; to trace in a laconic and strict manner their distinctive characters, and follow a course which shall correspond with the progress of the science and the eminent men who have contributed to its advancement; to single out the useful and obnoxious species, those which from their manner of living interest our curiosity; to mark the thousand sources where the knowledge of the original authors may be consulted; to render to Entomolo-

gy that amiable simplicity which she has had in the times of Linnæus, of Geoffrey, and of the first productions of Fabricius, and yet present her as she is to-day, with all the richness which she has acquired from observation, but without surcharging her with it; to conform her, in one word, to the model which I have under my eyes, the work of Cuvier—such is the end which I have taken upon myself to attain."

Dr. Fitch, to a large extent, accomplished this work; but his published treatises form only a small portion of his labors in that direction. One hundred note-books filled with complete and accurate entomological descriptions still remain on the shelves of his office, nearly or quite ready for the press; and it is much to be regretted that his life went out before he had finally completed and published them, and before he had arranged for the permanent retention in this country of his cabinet of insects.

The position of Dr. Fitch as State Entomologist, and the wide circulation of his published writings, brought to him from all quarters insects of rare and little known species to be named and classified. This, joined to his own untiring energy as a collector, enabled him to fill his cabinet to overflowing with the rarest and least known species of many lands. It is rich in all the orders, and especially so in useful, obnoxious, and curious species; and is probably one of the most valuable collections in this country, and one that it would be impossible to duplicate. As such it should be purchased and retained by the State.

It is impossible to summarize the benefits which scholars of Dr. Fitch's character confer upon the world. But it is safe to assume that they are of incalculable value. It is many millions the richer for Dr. Fitch's researches in the science of entomology, and would have been had he written only of the wheat-midge, the Hessian fly, and the currant-worm.

Dr. Fitch lived to the age of seventy. His life was full of strong, pure manhood—full of such labor and study as few men have physical power to endure—full of the gentleness, the kindliness, and peace which come of well-living, and full of the honors which his labors had earned. He died April 8, 1879, the death of a good man.

EDITOR'S TABLE.

THE SOLAR APPENDAGES.

FROM Professor Langley's address at the Saratoga Scientific Association, on the recent progress of solar physics, which is herewith printed, we get a vivid idea of the rapidity with which knowledge upon this subject has advanced within a very few years. We have found out more about the most conspicuous and familiar object in the universe in the last twenty years than all that was known before put together. A late writer in the London "Times" draws attention to the views now taken in regard to the solar surroundings. He considers that recent observations have tended toward marked agreement in the opinions entertained respecting coronal phenomena, and their relation to the zodiacal light. In presenting the results of observations on the eclipse of 1878 those are first taken which give the luminous effects displayed nearest the sun. Mr. Lockyer's drawing represents the black body of the moon as surrounded by a narrow ring of light, the inner corona. Outside this ring are three projections nearly in the ecliptic, and therefore coinciding with the axis of the zodiacal light. The longest of these projections extended to about one and a quarter of the sun's diameter, or not far from one million miles. General Myer described the corona as showing five radial lines of a golden color, beyond which in the direction of the ecliptic were prolonged bright silver rays. General Myer had observed effects so similar in the eclipse of 1869 as to make probable the inference that the objects extending far away from the sun are not subject to change like the prominences. Mr. Alfred C. Thomas also observed streamers of light extending for about one and a half time the diameter of the moon, and also in the plane of the ecliptic. Professor Cleveland Abbe saw the streamers which other observers had compared to a wind-vane, but he traced them to a much greater distance than they had done. The point of the vane as he saw it reached away from the sun to fully six diameters, or more than five million miles. The breadth of the vane, where it crosses the sun, is almost exactly equal to the solar diameter. On the other side of the sun the double streamer forming the tail of the vane did not extend more than three million miles. He also saw other luminous streaks at right angles with these, but of less breadth and length. Professor Langley saw the coronal light extending farther than the long rays observed by Professor Abbe. He traced it to a distance of twelve diameters of the sun on one side and three on the other. Its extension was in the direction of the ecliptic and the light resembled the zodiacal. At its extreme distance from the sun it was a faint and softly graduated luminosity, and not the separate rays discerned at about half the distance. Professor Newcomb saw a similar luminosity, and traced it to the same distance from the sun that had been assigned by Professor Langley. The results are thus summed up by the "Times" writer:

> From a comparison of all the observations the following important conclusions seem established beyond all possibility of doubt or question: Outside the solar sierra, averaging some 6,000 or 7,000 miles in height, comes the prominence region, extending about 100,000 miles from the sun's surface. Outside this comes the inner corona, shining in part with its own light, sometimes coming chiefly from multitudes of solid or liquid bodies in a state of incandescence, sometimes chiefly from glowing vaporous matter. This region

extends from 200,000 to 500,000 miles from the sun. Beyond the inner corona is the outer corona as already known and photographed during the eclipses of 1870 and 1871, and extending about a million miles from the sun. But far outside the outer corona there is a region occupied by matter so situated and so illuminated (or possibly self-luminous) as to present the appearance of long rays extending, if we may judge from observations hitherto made, directly from the sun to a distance of 5,000,000 miles. Outside this region again lies another in which, whether by the combination of multitudes of such rays as are seen separately close to the sun or through the presence of matter in other forms, a softened luminosity prevails which during total eclipse can be traced along the zodiac at least 10,000,000 miles from the surface of the sun. Lastly, from observations made during evening twilight in spring and during morning twilight in autumn (at which twilight hours the zodiac near the sun is most nearly upright during the year) we can trace the extension of the zodiacal luminosity seen by Langley and Newcomb, to distances exceeding seven or eight times at least those to which they traced it during total eclipse. Nay, there are reasons for believing that at times this luminosity has been traced to such a distance from the sun as to show that the zodiacal matter extends much farther from him than the orbit of our own earth.

Now, in one sense, the relations here presented are not new. The zodiacal light has been known from the time of Childrey, if not from that of Tycho Brahe. Mathematicians have long seen that it must belong to a solar appendage, rejecting utterly the doctrine advanced by some that it comes from matter traveling round our own earth. Again, the long coronal rays had been very confidently regarded by most mathematical astronomers, and indeed by all who had sufficiently studied the evidence, as belonging to matter near the sun. And though the zodiacal had never before been recognized during totality, and so the gap between the outermost coronal rays and the innermost part of the zodiacal seen during twilight had never been observationally filled up, yet the mind's eye of science had clearly discerned even that portion of the zodiacal. Still the recognition of the whole range of solar surroundings, in such sort that no question can any longer, it should seem, be raised as to their reality, even by those least able to follow scientific reasoning, can not but be regarded as an important step.

CONCERNING HONORS TO SPIES.

Mr. Cyrus W. Field has dedicated a memorial stone to the memory of André. It marks the place of his execution and burial. It was uncovered at noon, October 2d, as nearly as possible at the same hour that André was hanged. But few persons were present, and not a word was spoken by any one.

The monument is a plain polished block of Maine granite, five feet in height and three and one half feet square. On the side toward the west is the following inscription:

"Here died, October 2, 1780, Major John André, of the British Army, who, entering the American lines on a secret mission to Benedict Arnold for the surrender of West Point, was taken prisoner, tried and condemned as a spy. His death, though according to the stern code of war, moved even his enemies to pity, and both armies mourned the fate of one so young and so brave. In 1821 his remains were received at Westminster Abbey. A hundred years after his execution this stone was placed above the spot where he lay, by a citizen of the States against which he fought, not to perpetuate the record of strife, but in token of those better feelings which have since united two nations one in race, in language, and in religion, with the earnest hope that this friendly union will never be broken."

Beneath was the name—

"Arthur Penrhyn Stanley, Dean of Westminster."

On the south side the inscription reads as follows:

"Sunt Lacrymæ rerum et mentem mortalia tangunt."—Virgil, "Æneid," I., 462.

The only other inscription is upon the north side, and is this:

"He was more unfortunate than criminal. An accomplished man and a gallant officer."

George Washington.

An inscription will be placed on the east side next year, the centennial of the execution.

The spot where the monument stands

is about two miles from the Hudson River, and is high ground, overlooking a beautiful country. Mr. Field has purchased thirteen acres of land surrounding it, which he proposes to convert into a park; and, when completed, he will present the property to the citizens of Tappan. The shaft is to be surrounded by an iron railing, and around it at the cardinal points are to be planted four trees, oaks or elms, two English and two American.

The remains of Major André repose with the illustrious dead in Westminster Abbey. They were exhumed and carried to England in 1821 by the Duke of York, who was sent over by the British Government for that purpose.

We are glad that this monument has been erected. It indicates the strengthening and a triumph of the nobler sentiments of civilization and a decline of the intensity of international prejudice. And it is especially fitting that Mr. Cyrus W. Field, to whom we so largely owe that grandest of all unifying agencies among nations, the intercontinental telegraph, should have carried out the spirit of this great work, by doing honor to the memory of an enemy of his country, which has been especially odious for these hundred years. To be sure, André was hanged, but that was merely one of the chances of war. Washington would have been hanged also, if the luck of war had run differently. Is it not time to begin to judge of the merits of men independently of the casualties that happen to befall them? We should be sorry not to go behind the gallows, the cross, and the axe, in estimating the characters of their victims.

But another aspect of the matter is noteworthy: Mr. Field is reported to have said that, if he were granted permission, he would erect a monument to the memory of Nathan Hale, the American spy, who was hanged in the public grounds near Hamilton Park in this city. It would have been especially graceful if Dean Stanley had reciprocated Mr. Field's generosity by taking the initiative as an Englishman in doing honor to the memory of Hale. But that was not necessary. The main thing is the concession that the monument was deserved. No one will deny that the young American who gave his life for his country, and only lamented that he had but one to give, well deserves a monument.

But in thus doing honor to the memory of spies it is important to discriminate between the motives that animate them and the traits of character displayed. The military spy represents his country's side in war, and is justified by the ethics of patriotism. The soldier encounters the chance of an honorable death on the field of battle, but is safe if taken prisoner. The spy, on the other hand, if he fails, is certain of an ignominious death. He takes a deadlier risk than the soldier, and requires a firmer courage to meet it. Let the military spy, therefore, who perils and loses his life, have his posthumous honors, the honors due to courageous, unselfish conduct, on whatever side enlisted.

But there is another class of spies who should be hanged without the benefit of monuments; we mean Sherman's custom-house spies. We have revenue laws so scandalous that the regularly appointed officers are ashamed to enforce them. They shrink from branding all American citizens upon their return home after foreign travel as thieves and swindlers, and so the Government sets spies upon its own officers to see that they carry out our revenue regulations in the full measure of their meanness. These spies, employed by Government in time of peace, from purely sordid considerations on both sides, and who are destitute of every manly impulse, abundantly deserve the ropes they do not get, and the spies that are hanged should not be disgraced by being classed with them.

VENTILATING STOVES.

THE season has again come which drives people into their houses to pass a large portion of their time in closed apartments where they can keep warm. But the house so tight as to exclude the cold excludes also the air, so that good warmth is apt to involve bad breathing. There will be renewed complaints of deficient ventilation, and plenty of grounds for them. And as people suffer they will exclaim against the backwardness of the art of ventilating, and wonder that science does not bring forward some satisfactory system of furnishing fresh air and plenty of it to those who are shut up in houses during the cold season. Yet the inventors and constructors are ahead of the people, and already furnish many excellent devices which are not appreciated or used. It is perfectly well known, not only that fresh air ought to be furnished to inhabited apartments, but how much should be furnished in given conditions, and how it may be effectually introduced. The problem was in fact practically solved more than a hundred years ago with the invention of the Polignac fireplace, which not only warmed the room where it was set up, but provided for ventilation by bringing in a stream of air from without through suitable ducts, warming it and then throwing it into the apartment. Various modifications of this contrivance have appeared in the shape of ventilating grates which furnish warm fresh air to occupied rooms. But grates are constantly put into houses now which have no more reference to ventilating arrangements than as if nothing of the kind had ever been thought of. Steam and hot-water apparatus, and furnaces to warm large quantities of air for distribution through buildings, have come into extensive use, by which heat and adequate ventilation are well secured; but, after all, these engines are employed by but a small part of the population. A large proportion of the inhabitants of towns, and the great majority of country people, use stoves for warmth in cold weather. But here, again, we see the same neglect in providing fresh air to breathe that is observable in the current use of grates. Stoves are economical and efficient means of warming, and their use for this purpose must long continue. But they are generally non-ventilating, and give us the worst effects of bad air. They draw off from apartments only the air required for combustion, and which is replaced by more air from without to be used for the same purpose. Then there is complaint again, and with abundant reason, of bad ventilation. It seems to be forgotten that there are such things as ventilating stoves. But they have long been in use. The Franklin stove as originally constructed had a provision for ventilation. Ruttan's "Air Warmer" is a double box-stove, which heats by radiation, and also by air which is brought from without, warmed by passing between the inner and outer plates, and delivered into the apartment. The inventor, however, was so intent upon a "system of ventilation" which implied the adaptation of the house to it, that he failed to make his stoves readily available for ordinary use.

The best contrivance we have seen of this kind is the ventilating stove or fireplace known as the "Fire on the Hearth." This combines the advantages of a stove within the room to warm by radiation, a grate giving an open fire, which is prized by many, and a passage or chamber open below and above through which warm air ascends into the room. An opening in the floor with a duct leading to the outside of the house brings in a supply of fresh air which is passed through the stove, warmed, and streams into the apartment. We have tried this stove, and found it satisfactory, both as a heater

and a ventilator. We used one of moderate size, which, as tested by the anemometer, gave from eight to ten thousand cubic feet of air per hour in the room, and thus secured excellent ventilation. The difference between an ordinary stove and this ventilating stove in an occupied apartment was most marked to all the inmates, while to gain its advantages it is only needful to incur the small outlay necessary for bringing in the outer air. Fresh air is happily very cheap, but it must have a channel for introduction. If people will not go to the small trouble and expense required to give it entrance, they should not complain of the difficulties and imperfections of ventilation.

THE WORKS OF PROFESSOR VAUGHAN.

We have received various communications from widely different and distant sources in relation to the reputation and works of the late Professor Daniel Vaughan. Severe animadversions have been passed upon the depreciatory tone of comment that has been indulged in with regard to his personality and life; and there has been inquiry as to where his writings may be obtained. Several suggestions have been made respecting the publication of an edition of the most important and popular of his scientific contributions. A correspondent of Salem, Massachusetts, suggests that a very attractive and valuable volume could be made up by his papers on "The Tides," "The Rings of Saturn," "The Origin and End of the World," "The Advent and Appearance of New Stars," "The Nebular Hypothesis," "The Plurality of Worlds," "The Primitive Earth," "The Ancient Atmosphere," "Physics of the Internal Earth," "Volcanoes," "The Moon," "Revelations of Spectrum Analysis," and "The Catastrophes in Celestial Space."

These are certainly interesting topics, and they were handled by Professor Vaughan not only with the ability of an able expositor, but with the freshness of an independent thinker, who had formed his own opinions upon many of the questions involved. Professor Vaughan, as we, however, understand, left no property to pay for the publication of his works, and whether such a volume can be issued will depend upon how publishers regard the venture, or whether he has any friends sufficiently interested in his memory and productions to coöperate in bringing out a collection of his essays.

LITERARY NOTICES.

ETHICS, OR SCIENCE OF DUTY. By JOHN BASCOM, author of "Principles of Psychology," etc. New York: G. P. Putnam's Sons. Pp. 385. Price, $1.75.

DR. BASCOM has here given us a freshly-reasoned and excellent manual of morals. It is attractively written, and very judicious as an exposition of practical duty.

But the title chosen raises expectations, at the present time, which the work seems to us hardly to fulfill. The author recognizes that the subject he is dealing with belongs among the sciences, and is therefore a branch of improvable or progressive knowledge. He, moreover, admits that there is some force in the claim that ethics requires both a new foundation and a new method. The subject is therefore confessedly in a state of transition, or is undergoing a development such as all sciences experience from a less perfect to a more perfect form. Dr. Bascom does not give sufficient prominence to this fact and its important implications. Had he confined himself merely to summarizing the empirical rules of morality as they have been arrived at in social practice, this objection would be less pertinent; but he goes analytically into the subject, works out its principles, reviews ethical systems, discusses ethical methods, and reasons his way to full conclusions respecting the right and wrong of conduct, and the grounds of moral obligation. The whole subject being thus opened, we think the author should have gone fur-

ther in the scientific direction than he has seen fit to go. He should have placed his exposition upon a scientific groundwork, or have given the reasons for not doing so. His omission is the more surprising when we observe how far he has actually proceeded in the right direction.

It is sufficiently obvious that ethical method passes to a new stage of development with the establishment of the doctrine of evolution. If evolution be true, the foundations of old systems are subverted, and it is necessary to build anew. When he wrote his late elaborate book on "Methods of Ethics," Mr. Sidgwick could not see that evolution had much to do with the subject. If the doctrine had been developed in the universities, he would have probably found its bearings more important. He has found more in it for his second edition, and will be likely to discover still more for the third. Should he finally be compelled to admit that the relation is fundamental, it will be but another instance, of which the history of science is so full, in which what was at first insignificant comes to be supreme.

Dr. Bascom begins better. His first chapter is on "The Remote or Physical Conditions of Duty"; and if this starting-point of a treatise on morality would have seemed surprising a generation or two ago, still more surprising would have been the considerations he has brought forward in this chapter. It does not require a very long memory to recall the time when evolution in any form and to any degree was visited with universal malediction. It was the one poisonous heresy of thought that could not be too severely denounced. But now we see the able President of an influential university planting this doctrine in the opening chapter of a text-book upon morals! If Dr. Bascom assumes rather than formally avows the doctrine, he is but doing what Professor Marsh says the whole scientific world must henceforth do —assume the theory, and go on. But let the author here speak for himself. He says: "The body has been brought up to its present serviceableness through so protracted a development, and the power of the mind is now so measured by it, and is hereafter to be so much extended by means of it, that a brief survey of this middle term between the spiritual and physical worlds becomes very desirable. . . . This power" (the plastic power of life) "has as many forms as there are kinds of living things. In the higher varieties of animals this plastic power which controls the structure, which receives and transmits tendencies, has been built up into a wonderfully complex and mysterious potency by the entire development of life from its first appearance on the globe. This is plainly true if we accept the theory of evolution with definite or indefinite increments. It is also true, though less manifestly so, if we believe in a series of distinct creations. . . . The first term in this plastic power is an organic one. This has every grade of complexity, from that shown in a globule of protoplasm to that manifested in the human body. In it functions and organs are developed coetaneously, are united into a life increasingly complex and single, are left susceptible to a thousand modifying circumstances, and are transmitted with a full entail of established tendencies." After pointing out the gradations of unfolding life through automatic action, instinct, and the higher complexities of mind, the author says: "Another consideration of utmost moment, in estimating our moral activity in its relations to the physical world, is that of inheritance. The power of to-day is not that of a century since, nor will it be that of a century to come. Nor are these forces, in their transition from one stage to another, inapproachable by man. On the other hand, the stream of descent is flexible at every point, as flexible as it can be and retain its general direction. Physical descent is made up of three laws. The primary and central one is, that all organic powers tend to pass from parent to offspring. There is a momentum in the waters of life by which they flow steadily along the slopes prepared for them. A second law, which directly modifies the first, and without which it would lose much of its beneficence, is, that organs and functions are subject to changes, which changes may be transmitted. A third law, of less significance, yet one of moment, is, that living forms easily revert to a long antecedent state. As the new conditions impressed upon living things, which

are shaken off by this atavism, have reference to secondary adaptations, to new circumstances, and, in many cases, to the wants of man, this reversion is virtually a retrogression under feeble progressive forces. . . . New powers and new beauties may arise in the transfer of inheritance under inscrutable causes, and yet may be taken up by heredity and consolidated among more primitive endowments."

Now, having gone so far, we see not how Dr. Bascom could refrain from going further, and carrying out the doctrine to its logical consequences. For, if evolution be true at all, its truth is fundamental; and, if it have any influence upon ethical method, it must be a determining influence. If development be the method of nature, as Dr. Bascom tacitly admits, then must the moral sentiments and faculties of man be a product of it; and, if man's moral attributes have been evolved in immense time by slow experience, if our present morality has been derived from a lower stage by processes that are carrying it to a higher stage, then surely we have upon us the most important of all ethical questions, viz., by what causes and under what conditions is morality growing better? We have forced upon us the problem of the genesis of moral relations—how lower conduct is passing into higher conduct—what are the present imperfections of moral impulse and guidance which may be expected to disappear in the future—and how far is ethical requirement relative to the progress of the social state. It may not detract from the practical value of Dr. Bascom's manual, that these considerations are not pursued with the thoroughness and in the direction implied by his title and commencing chapter; but the failure of the exposition in this respect leaves it open to the charge of not fully representing the present state of ethical inquiry.

Dr. Bascom makes frequent and critical reference to the ethical views of Herbert Spencer as presented in his "Social Statics," published twenty-nine years ago. But it is nowhere stated, as we observe, that this was a transitional work that no longer accurately represents Mr. Spencer's views, and that, because of its unsatisfactoriness, he entered into a more extensive development of the subject, in which the "Principles of Morality" were to be treated after an exhaustive elucidation of the chief sciences that bear upon the subject. If it was worth while to quote Spencer at all—if his views of a generation ago have still sufficient insight to demand critical attention—it would certainly have been proper to state that the author held them so insufficient that he has devoted his life to the task of placing morals upon a sounder and more scientific basis than was possible when his first work was written.

FREEDOM IN SCIENCE AND TEACHING. From the German of ERNST HAECKEL. With a Prefatory Note by T. H. HUXLEY, F. R. S. D. Appleton & Co. Pp. 121. Price, $1.

THE collision of two such minds as those of Virchow and Haeckel over the evolution question could not fail to strike fire and create light. Much able discussion has followed, in which certain important aspects of the question have been scanned and sifted with a thoroughness that would hardly have been secured in the absence of conflict. The reply to Virchow that has been called out from Haeckel and fills this volume is an extremely interesting and instructive contribution to the popular literature of the subject.

It needs hardly to be said that in his celebrated address, which has been received with such favor by the non-scientific portion of the public, and by such scientific persons as are dominated by traditional ideas, Virchow took the ground that evolution is an hypothesis not proved, and that therefore it should not be taught in the German schools; that the evidence of anthropology is thus far against the doctrine of the derivation of man from lower forms of life; and, finally, that there is such an affiliation of Darwinistic theories with modern communism as to raise the question whether the state is not justified in interfering for the suppression of a dangerous teaching. For the reply that Professor Haeckel makes to Virchow's charge that evolution is an "unproved hypothesis," we must refer the reader to the book, which is valuable as showing—1. What kind of evidence is required; 2. That it is abundant in quantity; and, 3. That the difficulty with

Virchow is, that he don't understand or appreciate it. In regard to the anthropological objection, Professor Huxley declares in his preface that Virchow is entirely in the wrong. Authority is here opposed to authority; and Huxley asserts that all we know concerning the most ancient men harmonizes with the view that they have originated under the general law of evolution.

In regard to Virchow's attempt to bring evolution into reproach by associating it with communism, Professor Huxley says: "I think I shall have all fair-minded men with me, when I also give vent to my reprobation of the introduction of the sinister arts of unscrupulous political warfare into scientific controversy, manifested in the attempt to connect the doctrines he (Haeckel) advocates with those of a political party which is at present the object of hatred and persecution in his native land."

Professor Haeckel in dealing with this charge says that "those two theories are about as compatible as fire and water," and remarks upon the subject as follows: "With all these empty accusations, as with all the empty reproaches and groundless objections which Virchow brings against the doctrine of evolution, he takes good care in no way to touch the kernel of the matter. How, indeed, would it have been possible, without arriving at conclusions wholly opposed to those which he has declared? For the theory of descent proclaims, more clearly than any other scientific theory, that the equality of individuals which socialism strives after is an impossibility; that it stands in fact in irreconcilable contradiction to the inevitable inequality of individuals which actually and everywhere subsists. Socialism demands equal rights, equal duties, equal possessions, equal enjoyments for every citizen alike; the theory of descent proves, in exact opposition to this, that the realization of this demand is a pure impossibility, and that in the constitutionally organized communities of men, as of the lower animals, neither rights nor duties, neither possessions nor enjoyments, have ever been equal for all the members alike, nor can ever be. Throughout the evolutionist theory, as in its biological branch, the theory of descent—the great law of specialization or differentiation—teaches us that a multiplicity of phenomena is developed from original unity, heterogeneity from original similarity, and the composite organism from original simplicity. The conditions of existence are dissimilar for each individual from the beginning of its existence; even the inherited qualities, the natural "disposition," are more or less unlike; how then can the problems of life and their solution be alike for all? The more highly political life is organized, the more prominent is the great principle of the division of labor, and the more requisite it becomes, for the lasting security of the whole state, that its members should be variously distributed in the manifold tasks of life; and as the work to be performed by different individuals is of the most various kind, as well as the corresponding outlay of strength, skill, property, etc., the reward of the work must naturally be also extremely various. These are such simple and tangible facts that one would suppose that every reasonable and unprejudiced politician would recommend the theory of descent and the evolution hypothesis in general as the best antidote to the fathomless absurdity of extravagant social leveling.

"Darwinism, I say, is anything rather than socialist! If this English hypothesis is to be compared to any definite political tendency—as is, no doubt, possible—that tendency can only be aristocratic, certainly not democratic, and least of all socialist. The theory of evolution teaches that in human life, as in animal and plant life everywhere and at all times, only a small and chosen minority can exist and flourish, while the enormous majority starve and perish miserably, and more or less prematurely. The germs of every species of animal and plant, and the young individuals that spring from them, are innumerable, while the number of those fortunate individuals which develop to maturity and actually reach their hardly-won life-goal is out of all proportion trifling. The cruel and merciless struggle for existence which rages throughout all living nature, and in the course of nature must rage, this unceasing and inexorable competition of all living creatures, is an incontestable fact; only the picked minority of the qualified 'fittest' is in a position to resist it successfully, while the great majority of the competitors must necessarily perish mis-

erably. We may profoundly lament this tragical state of things, but we can neither controvert it nor alter it. 'Many are called, but few are chosen.' The selection, the picking out of these chosen ones, is inevitably connected with the arrest and destruction of the remaining majority. Another English naturalist therefore designates the result of Darwinism very frankly as the 'survival of the fittest.' At any rate, this principle of selection is nothing less than democratic; on the contrary, it is aristocratic, in the strictest sense of the word. If, therefore, Darwinism, logically carried out, has, according to Virchow, an 'uncommonly suspicious aspect,' this can only be found in the idea that it offers a helping hand to the efforts of the aristocrats. But how the socialism of the day can find any encouragement in these efforts, and how the horrors of the Paris Commune can be traced to them, is to me, I must frankly confess, absolutely incomprehensible."

REPORT OF THE GEOLOGICAL SURVEY OF OHIO. Vol. III. Geology and Paleontology. Part I. Geology. Published by Authority of the Legislature of Ohio. Columbus: Nevins & Myers, State Printers. 1878.

THIS volume, the third in the series, fully sustains the high character which the two previous ones gave to this important work. The officers on whom rests the responsibility of the survey are J. S. Newberry, chief geologist; E. B. Andrews and Edward Orton, assistant geologists; T. G. Wormley, chemist; and F. B. Meek, Paleontologist. A corps of local and special assistants have rendered important service. Those of the corps who have contributed reports for the present volume are Messrs. John J. Stevenson, M. C. Read, A. W. Wheat, John Hussey, F. C. Hill, A. C. Lindemuth, J. S. Hodge, and F. Hesser. All of these reports are of a high order, and show in how careful and thorough a manner the work is being done. Reports of surveys of six counties are by the geologist-in-chief, who also contributes an important paper reviewing the general geological structure of the State. This paper is a wonderfully clear statement of the facts brought out by the local surveys, and of the conclusions which they suggest. It is the more interesting from the fact that it reviews conclusions presented in previous reports of the survey which had been criticised by several eminent geologists in other States. Much of the uncertainty which existed as to the age and geological equivalence of the Ohio rocks seems now to be removed. Concerning the Cincinnati uplift it is said that "the Cincinnati axis in Ohio is an anticlinal ridge of which the arched strata of the Cincinnati Group form the core." This uplift formed an elevated ridge through the Upper Silurian, Devonian, and Carboniferous ages. Many of the great deposits thin out on the sloping sides of this elevation. It constituted, indeed, two islands, one in Tennessee, the other in Kentucky and Ohio.

The Cincinnati Group referred to is shown to contain the characteristic fossils of the Hudson River Group, Trenton Limestone, and some which are found in the Black River and Birdseye Groups. But, says Professor Newberry, they are so intermingled as to make it impossible to identify any one of the subdivisions of the Cincinnati Group with either of the Lower Silurian Limestones of the East.

The Oolitic Iron-ore band of the Clinton is in Ohio, sometimes two or three feet in thickness, sometimes it is scarcely more than a ferruginous stain. This is stated to be in no sense a clay iron-stone, as has been suggested. It is a red hematite, and is called dye-stone ore in Tennessee. It is a marine not a marsh deposit, as shown by the fossils present. The iron was probably brought by drainage water from ferruginous districts and deposited.

The Corniferous Limestone in this State is a vast storehouse of fossils. Extensive collections of these will be fully described in Part II., which treats of paleontology. The land-plants found in this limestone at Sandusky and Delaware may have formed part of the luxuriant vegetation that covered the Cincinnati Island in the Devonian age, "the first land flora of which we have any traces in the United States."

Of the Huron Shale, much has been written. It occurs through Central Ohio in a line of outcrop with a maximum thickness of 350 feet. This formation is a nearly homogeneous bituminous shale, containing at

least ten per cent. of combustible matter. It is known in the Western States as black shale. Its precise geological horizon has been a subject of debate. The conclusion of the author is that "the Huron Shale of Ohio is made up of the black shales of the Lower Portage and Genesee." This deposit is an interesting one, from the fact that it is the most important source of supply of petroleum in this country, and also that most of the gas-wells of Ohio and Pennsylvania derive thence their supply of carburetted hydrogen.

If space permitted, we would be glad to present the views of Professor Newberry on the buried river channels—evidences of glacial action—clay deposits of the Drift age, and other subjects of interest to the geologist.

The reports of the local surveys by counties and districts are not only valuable to geologists, but are throughout of a thoroughly practical character. These include thirty-four counties of the State, besides reports of the Hocking Valley coal-field, Perry, and portions of Athens, and Hocking Counties, and the Hanging Rock District.

The reports of counties are illustrated by maps and charts, of which there are twenty, while fifty-three illustrations are printed with the text.

In the preface we are informed that Vol. IV., Zoölogy and Botany, is now in the printer's hands, and that Vol. V., Economic Geology, is in progress. Besides these, full and elaborate maps are in course of preparation.

The work has been issued in editions of 20,000 copies—to the honor of Ohio, be it said.

DISTRIBUTION OF HEAT IN THE SPECTRA OF VARIOUS SOURCES OF RADIATION. By WILLIAM W. JAYNES, Ph. D. Cambridge, Mass.: University Press. Pp. 24.

THIS pamphlet is the thesis presented to the Faculty of Johns Hopkins University by the author upon applying for the degree of Doctor of Philosophy. It first gives an account of former experiments to determine the distribution of heat in the spectrum; and then details the author's elaborate experiments for the determination of the result. There is one plate of apparatus and three large plates of the curves of thermal intensity in different parts of the spectral region. He thus sums up the inquiry: "In concluding this paper there is a strong temptation to speculate upon the meaning of the results obtained. That the geometrical form of the curve should be so nearly the same at all temperatures, and of the same *general* form for all substances, is a fact that probably must have an important physical interpretation. Does not the similarity of the curves for different substances show a similarity of movement of the ultimate components of the several substances, and so point to a similarity of ultimate composition of all matter, the slight differences in the grouping of these parts giving rise to the comparatively slight variations from the same form? Certainly this is not proof, but is it not evidence? And is it not probable that the superposition upon the radiations from the ultimate atoms of the radiations from the groupings of these atoms should cause the curve, as a whole, to move slightly to a shorter or longer wave-length, as the weight of a group is lighter or heavier? But I am aware that such speculations are founded on too insufficient data, and I offer these results merely as an experimental contribution to the science of radiant energy."

A DEFENSE OF PHILOSOPHIC DOUBT, being an Essay on the Foundations of Belief. By ARTHUR JAMES BALFOUR, M. A., M. P. Pp. 355. Price, $3.50.

THE object of this book would not be guessed from its title. It would be supposed to imply an argument in favor of skepticism, unbelief, or freethinking, in their customary applications to religious belief. But this is not the author's aim. On the contrary, the work is "a piece of destructive criticism" directed against the foundations of science. According to the author, it is the function of philosophy to give an account of the grounds of all belief and disbelief, and he labors to show that all the assumptions, principles, postulates, and criteria of truth that are usually taken as the basis of scientific knowledge are illusive and indefensible. The independent existence of an external world is denied; Kant, Hamilton, Mill, and Spencer are refuted; and the conclusion is reached that "science is a system of belief which, for anything we can allege to the contrary, is wholly without proof. The inferences by which it

is arrived at are erroneous; the premises upon which it rests are unproved." In a closing chapter on "Practical Results," the object of the work is disclosed—it is to harmonize religion and science by showing that religion is, at any rate, as well off for fundamental proofs as science. The conceptions of causality, uniformity, and permanence of order in nature being held as unproved, it is argued that supernatural interferences are logically admissible, and science and religion come into agreement by opening the doors of ancient and modern spiritualism.

THE SCIENCE OF THE BIBLE; or, An Analysis of the Hebrew Mythology, wherein it is shown that the Holy Scriptures treat of Natural Phenomena only. By MILTON WOOLLEY, M. D. Chicago: Knight & Leonard. Pp. 613. 8vo. Price, $4.

THIS elaborate book is alleged by its author to have had the following origin: Impressed by the sentiment that human nature in every age and country is much the same, he inferred that cosmologies and mythologies generally resemble each other. But, if this be so, then the Hebrew mythology is probably like the rest. So the author, after he was turned sixty, studied the Hebrew language to find the key to the Hebrew mythology and the Hebrew Scriptures. He claims to have succeeded, and this volume is the exposition of his view.

His notion is, that the Bible from beginning to end is but a mass of astronomic myths. On the cover of his book is stamped in gilt the old almanac diagram of the twelve constellations of the zodiac. This diagram reappears printed on a card at the close of the book, with a movable index to show the position of the sun throughout the year. Now, the writer claims that the whole Bible is to be interpreted as referring to the phenomena of the year—the changes of seasons, and the movements and places of the sun, moon, planets, etc. Armed with this clew, Dr. Woolley marches deliberately through the Old Testament, taking its narratives, "Creation," "Adam and Eve," "Cain and Abel," "Flood," "Tower of Babel," "Abram and Sarai," all the way through to "Job" and "Jonah," explaining, right and left, that what is really *meant* by these stories is to symbolize natural phenomena, terrestrial and celestial. For example: "'Now when Moses was grown' (i. e., when Aquarius rises heliacally as before the sun) 'he spied an Egyptian smiting a Hebrew, (winter smiting summer), 'and he looked this way and that way, and perceiving himself unseen' (the sun's rays hid him) 'he slew the Egyptian' (i. e., winter was followed by summer). 'But when he went out the second day' (i. e., after he passed the summer solstice) 'he saw two Hebrews' (the two halves of summer) 'striving together.' In attempting to pacify them he was reminded by the first half of summer, which witnessed his act, of his murder the day before, became frightened, and on learning that Pharaoh (the winter sun) intended to slay him, fled into the land of Midian (strife = the point between winter and summer). Here 'he sat down by a well.' Beer-sheba = the end of the *seventh* month, when the 'former rain' begins."

And so everything is construed. This exegesis would get monotonous and tiresome, but the author peppers his text so profusely with sarcasms at the expense of those who hold to the literal interpretation of Biblical narratives that the tediousness of the exposition is somewhat enlivened. The work evinces much ingenuity, great learning, and indomitable perseverance, though whether these accomplishments have been wisely expended in its preparation is perhaps a question.

NESTS AND EGGS OF AMERICAN BIRDS. By ERNEST INGERSOLL. Published in Parts, 50 cents each. Part I. Pp. 24, with Plates. Salem, Mass.: S. E. Casino.

HITHERTO there was no American work on the nests and eggs of birds, and information on that subject existed only in detached form in a multitude of publications or in the minds of ornithologists. Mr. Ingersoll has done a valuable service to ornithology by compiling the present work. When completed it will form a handsome volume, beautifully illustrated with tinted lithographs.

THE EVIDENCE OF THE SENSES. Inaugural Address before the Poughkeepsie Society of Natural Sciences. By W. G. STEVENSON, M. D., President.

DR. STEVENSON has here brought together many illustrations of errors and delusions

to which persons are often subject through defective action of the senses or false interpretations of their impressions. The facts are well interpreted and the accompanying comments judicious. He closes with a reference to spiritualism, and insists upon the need that it should be investigated by experts in matters of evidence.

HAECKEL'S GENESIS OF MAN; OR, HISTORY OF THE DEVELOPMENT OF THE HUMAN RACE. Being a Review of his Anthropogeny; and embracing a Summary Exposition of his Views, and of those of the Advanced German School of Science. By LESTER F. WARD, A. M. Philadelphia: Ed. Stern & Co. Pp. 64.

WE have read this able and admirable pamphlet with much pleasure. As a review of the principal works and a condensed exposition of the thought of the great German biologist, it is executed with judgment, and as an introduction to the study of evolution from a point of view with which the public is not generally familiar, it will prove useful and be welcomed by many readers. And to these merits of the *brochure* it must be added that it is clearly, effectively, and at times eloquently written. To any beginner who proposes to enter upon Haeckel's works, we should say, read this first; and that he will not be misled is sufficiently sure from the fact that Haeckel himself testifies to the substantial correctness with which this essay represents his position.

In stating this position, and in estimating Haeckel's claims, the writer inevitably opens the question of the claims of other men, and has to dwell on points of rivalry, priority, and originality. To whom belongs mainly the credit of working out the theory of dissent, or of establishing the doctrine of development? Thus far Mr. Darwin has had a virtual monopoly of the honor; but, while nobody will grudge him a liberal share of it, it begins to be seen that justice has something to do with it, and that there has been a great deal of loose exaggeration of Mr. Darwin's share in the work. Mr. Ward says that "Professor Haeckel is no mere disciple of Darwin," but has independently cultivated a great biological province, which bears directly upon development, but which Darwin hardly touched, viz., the province of embryology, which has for its object the study of transformations. This department Haeckel has made his own, and, as Mr. Ward shows, it furnishes the most impressive and overwhelming proofs of the truth of evolution that are to be gathered from any special source. This subject Mr. Darwin barely touched in his first book.

Mr. Ward recognizes that Darwin was "diaplomatic," and there can be no doubt, both that this is true and that it had much to do with the success of the "Origin of Species." In that work he invoked supernatural intervention where his scientific explanations were faulty; and he abstained from applying his theory to man. Haeckel had nothing of this quality; he was simply logical, and applied the law of descent to the human race at the outset. The consequence was, that he was bitterly attacked, not only by anti-Darwinians but also by Darwinians, who charged that "he was more Darwinistic than Darwin himself." Darwin afterward published "The Descent of Man," but Haeckel had to take the first brunt of the opposition in Germany.

In reviewing the history of the subject, Mr. Ward, following Haeckel, credits Erasmus Darwin, Goethe, and Lamarck with the honor of founding the doctrine of evolution. Lamarck's "Philosophie Zoölogique" was published just fifty years before the "Origin of Species," yet Mr. Ward goes so far as to say that every important principle embraced in the latter work is also contained in the former—except the principle of "natural selection." That principle, moreover, had been long recognized, and the doctrine of the fixity of species was undermined. Mr. Darwin and Mr. Wallace independently showed how "natural selection" may give rise to new species.

It would have afforded a still further illustration of the ripeness of thought upon this subject, and increased the equity of Mr. Ward's distribution of honors, if he had stated that, before Mr. Darwin had published at all on the subject, Spencer had drawn up in full detail his prospectus of the evolution philosophy, covering the whole ground, in ten volumes, and that the subsequent contribution of Mr. Darwin did not make it necessary to disturb the order of his work by so much as the introduction of an additional chapter. The new contribution fell into its proper place in an already organized body of thought.

EASY LESSONS IN POPULAR SCIENCE. By JAMES MONTEITH. New York: A. S. Barnes & Co. Pp. 252. Price, $1.

THIS is a very mixed book, as it treats of almost everything pertaining to air, land, and water. There is a good deal of geography, and something about ships, machinery, plants, animals, etc., etc., with maps and numerous woodcuts drawn in outline with a view to being copied by pupils upon the blackboard. The book can no doubt be made useful in the hands of judicious teachers, and the drawing exercises for which it provides are a good feature; but we do not think that its leading topics are the best to begin with in early science teaching, and it does not sufficiently provide for the direct study of things themselves.

HINTS TOWARD A NATIONAL CULTURE FOR YOUNG AMERICANS. By S. S. BOYCE. New York: E. Steiger. Pp. 69.

THE author's object here is to recommend and enforce a practical system of industrial education for American youth. He points out the deficiencies of the present modes of popular culture, and is favorable to the Kindergarten as a foundation in primary instruction.

SCIENTIFIC LECTURES. By Sir JOHN LUBBOCK. London and New York: Macmillan & Co. Pp. 187. Price $2.50.

OF this book, we *must* speak of Macmillan's part first. Paper, type, printing, and illustrations are elegant, so that to read it is a luxury. It is such a book as an English baronet might with graceful propriety present to his friends. Imported into this country, it comes rather expensive, considering the amount of its contents; but, happily, they are not of a sort that makes it necessary for anybody to procure the volume. Yet Sir John's lectures are very pleasant reading. He discourses of flowers, plants, and insects, and of the habits of ants, and gives us a great deal of curious and interesting information on those matters which he has made a special study. The fifth and sixth lectures are on "Prehistoric Archæology," and epitomize the views developed in the author's larger works, "Prehistoric Times" and "On the Origin of Civilization."

SCIENCE LECTURES AT SOUTH KENSINGTON. Vol. II. Macmillan & Co. Pp. 344. Price, $1.75.

THIS volume, like the one that preceded it, is filled with good, solid work. There is no attempt at extreme simplification, and not a word for effect; but each lecturer has aimed to make a sound, instructive presentation of his subject. The names are strong, and the subjects well chosen. President Spottiswoode treats of "Polarized Light"; Professor Forbes of "Thermal Conductivity" and "Thermo-Dynamics"; H. W. Chisholm of "Balances"; Professor Pigot of "Geometrical and Engineering Drawing"; Froude of "The Laws of Fluid Resistance"; Dr. Siemens of "The Bathometer"; Burrett of "Sensitive Flames"; Pigot of "Lighthouse Illumination"; Burdon-Sanderson of "Apparatus for Physiological Investigation"; Lauder Brunton of "Apparatus for Physiological Chemistry"; Macleod "On Audiometers"; and Roscoe on "Technical Chemistry."

ZOÖLOGY OF THE INVERTEBRATE ANIMALS. By ALEXANDER MACALISTER, M. D. Specially revised for America by A. S. PACKARD, Jr., M. D. Pp. 143. Price, 60 cents.

THIS volume belongs to Holt's series of handbooks which claim to be intermediate between the larger text-books and the so-called "primers." In what way the American editor has "revised" the English work for use in this country is not explained, nor does it much matter; the book is well adapted to introduce pupils into the study of zoölogy, as it will attract and interest them. The information furnished has been selected with good judgment, and is no doubt entirely trustworthy.

PUBLICATIONS RECEIVED.

The Young Folks' Cyclopædia of Common Things. By John D. Champlin, Jr. With numerous Illustrations. New York: Holt & Co. 1879. Pp. 695. $3.

Key to the Universe, or a New Theory of its Mechanism. By Orson Pratt, Sen. Salt Lake City: The Author. 1879. Pp. 118. $1.50.

Primitive Manners and Customs. By J. A. Farrer. New York: Holt & Co. 1879. Pp. 345.

The Value of Life: Reply to Mallock's Essay "Is Life worth Living." New York: Putnam's Sons. 1879. Pp. 253. $1.50.

Illustrated Dictionary of Scientific Terms. By William Rossiter. New York: Putnam's Sons. Pp. 350. $1.75.

Wonders of the Flora. By H. A. Kreeken. Dayton, O. 1879. Pp. 204. $1.50.

The Rosicrucians, their Rites and Mysteries. By Hargrave Jennings. With numerous Illustrations. New York: J. W. Bouton. 1879. Pp. 388.

Report of the Commissioner of Education for the Year 1877. Washington: Government Printing-Office. 1879. Pp. 850.

First Step in Chemical Principles. By H. Leffmann, M. D. Philadelphia: E. Stern & Co. 1879. Pp. 52. 50 cents.

Ancient Pagan and Modern Christian Symbolism. By Thomas Inman, M. D. With Illustrations. New York: J. W. Bouton. 1880. Pp. 147.

Lessons in Inorganic Chemistry. By W. G. Valentin. With Illustrations. New York: Putnam's Sons. 1879. Pp. 186. $1.

Report on Copper-Tin Alloys. By R. H. Thurston. Washington: Government Printing-Office. 1879. Pp. 300.

Local Government. By R. P. Porter. From "Princeton Review." Pp. 24. 5 cents.

The Public Library and the Common Schools. By C. F. Adams, Jr. Boston: Estes & Lauriat. 1879. Pp. 52. 25 cents.

The South Pass Jetties. By M. E. Schmidt. From "Transactions of the American Society of Civil Engineers." Pp. 36, with Plates.

Address to the New Orleans Sanitary Association. By Dr. J. H. Rauch. Pp. 13.

Domestic Sanitation. New Orleans: Graham Print. 1879. Pp. 20.

Milk and Dairies in New Orleans. New Orleans: Rivers Print. Pp. 16.

Tracheotomy with Galvano-Cautery. By Dr. W. A. Byrd. From "St. Louis Clinical Record." Pp. 7.

Shall the Metric System be made compulsory? By H. T. Blake. From "The New-Englander." Pp. 22.

Petroleum. By P. Schweitzer. Columbia, Mo.: "Statesman" Print. 1879. Pp. 64.

Report of the Entomologist. By C. V. Riley. Washington: Government Printing-Office. 1879. Pp. 52, with Plates.

Phenol. By David Cerna. From "Philadelphia Medical Times." Pp. 5.

American Industries and the Proposed Franco-American Commercial Treaty. San Francisco: "Alta California" Print. Pp. 211.

History of Massage. By D. Graham, M. D. New York: W. Wood & Co. 1879. Pp. 80.

The Pocasset Tragedy. By W. Denton. Boston: The Author. 1879. Pp. 33.

Biographical Notice of Joseph Henry. By Joseph Lovering. Pp. 11.

Sanitary Condition of Montreal. By F. P. Mackelcan, C. E. Montreal: Lovell Print. 1879. Pp. 41. 10 cents.

The More Common Families of Insects. By L. C. Wooster. Whitewater, Wis.: "Register" Print. 1879. Pp. 52.

POPULAR MISCELLANY.

Experiments with Platinum.—A paper by Mr. Edison, on the behavior of platinum under the influence of the electric current, was read at the last meeting of the American Association by Professor F. R. Upham, the author being absent. Having found that a platinum wire, heated by the electric current and suspended in the air, loses weight in proportion to its mass, its heat, and the length of time during which the current passes through it, Mr. Edison took a platinum wire $\frac{10}{1000}$ of an inch in diameter, and wound it in the form of a spiral one eighth of an inch in diameter and one half inch in length. The two ends of the spiral were secured to clamping-posts, and the whole then covered with a small glass shade. After the spiral had been made incandescent for twenty minutes, the shade opposite to the spiral on both sides was slightly darkened, and after five hours was no longer transparent, a film of the metal having been deposited on it. Mr. Edison is convinced that this effect, namely, the loss of weight in the spiral, is due to *the washing action of the air*, to the wearing away of the surface of the platinum by the impact of the stream of gases upon the highly incandescent surface, and not to volatilization. That this supposition is correct is shown by the very different behavior of platinum wire *in vacuo*. Mr. Edison placed a spiral of platinum in the receiver of a common air-pump, and arranged it so that the current could pass through it while the receiver was being exhausted. At the pressure of two millimetres the spiral was kept incandescent for two hours before the deposit on the glass shade became visible. In another experiment, when the exhaustion was higher, the deposit became visible only after five hours. The same paper contained observations on other phenomena of still greater interest. It has been known for some time that platinum, when long subjected to a high temperature, becomes disintegrated. A platinum wire which has been heated to incandescence for twenty minutes, on being examined under a microscope, is seen to be full of cracks, and appears shrunken. If the current is continued for a considerable time the wire will fall to pieces. Now, Mr. Edison finds that this shrinking and cracking of the wire are due entirely to the expansion of the air in the pores of the metal, and its contraction on the escape of the air. If these air-spaces be previously eliminated, the platinum can be heated to incandescence without disintegration. How this is to be done is best told in Mr. Edison's own words:

"I had made a large number of platinum spirals, all of the same size and from the same quality of wire; each spiral presented to the air a radiating surface of three sixteenths of an inch; five of these were brought by the electric current up to the melting-point, the light was measured by a photometer, and the average light was equal to four standard candles for each spiral just at the melting-point. One of the same kind of spirals was placed in the receiver of an air-pump and the air exhausted to two millimetres; a weak current was then passed through the wire slightly to warm it for the purpose of assisting the passage of the air from the pores of the metal into the vacuum. The temperature of the wire was gradually augmented at intervals of ten minutes until it became red. The object of slowly increasing the temperature was to allow the air to pass out gradually and not explosively. Afterward the current was increased at intervals of fifteen minutes. Before each increase in the current the wire was allowed to cool, and the contraction and expansion at these high temperatures caused the wire to weld together at the point previously containing air. In one hour and forty minutes this spiral had reached such a temperature without melting that it was giving a light of twenty-five standard candles, whereas it would undoubtedly have melted before it gave a light of five candles had it not been put through the above process. Several more spirals were afterward tried, with the same result. One spiral, which had been brought to these high temperatures more slowly, gave a light equal to thirty standard candles. In the open air this spiral gave nearly the same light, although it required more current to keep it at the same temperature. Upon examination of these spirals, which had passed through the vacuum process, by the aid of a microscope, no cracks were visible; the wire had become as white as silver, and had a polish which could not be given it by any other means. The wire had a less diameter than before treatment, and it was exceedingly difficult to melt in the oxyhydrogen-flame. As compared with untreated platinum, it was found that it was as hard as the steel wire used in pianos, and that it could not be annealed at any temperature."

Animal Mounds in the Pyrenees.—An interesting paper was read by Dr. Phené at the last meeting of the British Association, on a discovery of animal mounds in the Pyrenees. The author said that this discovery was, in a great measure, due to the description given by Sir Vincent Eyre in 1869 of a remarkable custom of burning living serpents at a particular spot in the Pyrenees. While investigating the region around this place of immolation, Dr. Phené found in certain directions indications which always accompany animal mounds. The churches abounded in features expressive of the subversion of a pagan faith, of which the serpent or dragon had evidently been the central point. Following the track where these indications were plainest, he had come upon mounds as distinct in resemblance to animal forms as any of the American mounds: they were altogether artificial, and shaped into an appearance of animal outline so real as to seem like life. In the parts forming the heads the chamber had been replaced by an arched chamber of Roman work, in another by a descent of several feet into the body of a small church. On the spire of the best preserved animal mound had been a tumulus in which, the *curé* of the church informed Dr. Phené, had been found several of the most primitive cinerary urns, containing bones, Celtic articles, and above them objects of the Gallo-Roman description, and again above these later or Christian Roman works. One of the most interesting of the latter had been laid aside, and the *curé* sought it out for Dr. Phené among some *débris;* it was the stem of an ancient cross, and on it were sculptured serpents—not in the usual position of subjection to a superior power, but evidently as being in a condition of supremacy; but, as there were also several dead ones represented, it might be that the sculpture figured the condition of the real serpents before and after the ceremony of burning. In the district there were many emblems of the serpent or dragon, and the mounds were distinctly of such a form. On the mountains overlooking these mounds were a number of stone circles, like those so well known in Britain. Dr. Phené promised to give further details in a paper which he was to have read before the Congress of Americanists at Brussels.

Carl Vogt on the Archæopteryx.—The Congress of Swiss Naturalists held its sixty-second annual meeting this year at St. Gall. Professor Carl Vogt delivered one of the public lectures, choosing for his subject the archæopteryx, an animal intermediate between birds and reptiles. Of the archæopteryx there exist only two (fossil) specimens, one of which, that first discovered, is in the British Museum; the other, which is by far the more perfect of the two, was discovered a few years ago at Solenhofen, Germany. It is the property of Dr. Haeberlein, of Pappenheim. It was once fondly hoped that the Emperor of Germany would purchase this treasure and preserve it for the Fatherland; but, as Professor Vogt remarks, a petrified cannon or musket would have found infinitely more favor in that quarter! The naturalists who studied the specimen in the British Museum pronounced this Jurassic animal to be a bird, inasmuch as it had a beak, nails, and feathers. But the Solenhofen archæopteryx proves, undoubtedly, that the animal was a bird-like reptile, of the size of a pigeon, which had both scales and feathers, a beak provided with teeth, armed wings, bird-like feet with nails, and a reptilian tail, consisting of twenty vertebræ.

Stilling the Waves with Oil.—A few months ago we printed some observations on the use of oil as a means of calming a tempestuous sea in cases of danger to mariners. A later number of the journal (Chambers's) from which those observations were quoted contains the official report of a ship-master, whose vessel appears to have escaped disaster through the timely use of oil in a storm. This report was sent to "Chambers's Journal" by Mr. Sprunt, British Vice-Consul at Wilmington, North Carolina. It is as follows:

"British brigantine Gem, of Sackville, New Brunswick, Richardson, master. On the 1st of April last, bound from Wilmington, North Carolina, for Bristol, took a heavy gale of wind about a degree to the eastward of Bermuda, from the south, veering rapidly to the northwest, whence it blew a hurricane for thirty-six hours, with a cross-breaking sea, ship laboring heavily—'started' the after-house and boats, stove lazarette hatch, and took try-sail from the mast. All hands aft in the cabin in case the sea should break over and carry away fore-house. 8 P. M., sea getting worse, the master thought of resorting to the oil experiment, which he had read of in 'Chambers's Journal.' Had a canvas bag prepared, holding about three quarts of kerosene oil, with a rope of six fathoms attached, and kept trailing to windward; the oil leaking through the canvas greatly broke topping sea, and made matters much more favorable for the ship. This was kept up through the night; and at 3 A. M. on the 2d of April the weather began to moderate. The mate, who had himself lashed to the rigging during the whole of his watch, believed with the captain that the resort to the oil saved the ship, as such fearful weather had never during the captain's experience of fourteen years been witnessed by him. A drop of the oil will smooth about four feet circumference of sea. Captain Richardson suggests that a canvas bag to hold about six gallons is the best size, pierced with small holes with a penknife, the holes to be enlarged as the canvas becomes wet and its texture closer."

Petroleum for Steam-making.—A successful exhibition was recently made at Pittsburg of a method of using petroleum as fuel on board steamers. In its main features this new method resembles other methods which have been tried with more or less success—air, steam, and oil-spray being injected into a suitable fire-box. The spray is said to be immediately converted into inflammable gas, becoming a pure, bright, powerful flame, free from smoke. To accomplish this result, the inventor resorts to a very simple contrivance, described as follows in the "Journal of the Franklin Institute": A small hole is drilled into the iron front of the fire-box, and into this passes a tube which branches, as it leaves this point, into two pipes. One of these connects with the boiler itself, and the other with a receptacle containing crude oil. At the junction of these pipes there is an aperture for the admission of atmospheric air. Valves of peculiar construction regulate the quantity of steam or oil admitted to the furnace. Our contemporary

gives the following account of the experiment made to test the efficacy of this method of employing petroleum in place of coal: "The little steamer Billy Collins was selected by Mr. Campbell for the test. A preliminary blaze of wood under the boiler raised the small quantity of steam necessary to start the burner into operation. The oil-valve was opened a trifle, the steam-valve ditto. The petroleum trickled into the feed-pipe, was caught up by the steam, and both plunged into the depths of the fire-box, a mass of many-tongued, roaring, brilliant flame. As the pressure of steam increased, this flame grew in fury and intense heat. The needle of the steam-gauge climbed rapidly up the dial, and in twenty minutes the safety-valve blew off at 120 pounds pressure. . . . To ocean-going steamers this device must prove of extraordinary interest. A tank of oil, situated at a remote end of the ship, would hold fuel sufficient for a double trip, and supplant the great coal-bunkers with their attendant dirt."

What Nordenskjöld has done.—A current misapprehension of the work done by Nordenskjöld (pronounced *Nordenshuld*), in his recent memorable voyage, is corrected by the "Pall Mall Gazette." He is supposed to have *discovered* the "North-east Passage." He has *discovered* nothing, not even the shore along which he sailed. Every part of his route was known before, and the whole coast-line had been laid down by the expeditions which, for more than three hundred years, have penetrated from the east and west, or, descending the great Siberian rivers, have crept along the European and Asiatic arctic shores in boats or in dog-sleds. What Nordenskjöld has actually done is to have sailed, in one continuous voyage and in one ship, from the Atlantic to the Pacific, and to have made *en route* a series of scientific collections and observations such as no other explorer in these seas—unless, perhaps, himself in former voyages—had been able to carry away. Professor Nordenskjöld is sanguine that he has proved the feasibility of the northeast passage for ships during most seasons. This the "Pall Mall Gazette" pronounces too hopeful a view, and assuredly a passage which requires over twelve months for its accomplishment can hardly be called "feasible" in any remunerative sense. But one thing is made clear by this voyage, namely, that the great Siberian rivers drive the ice off the coast during several of the late summer and autumn months, and that the Yenisei and Obi may be reached during average years. So confident is the Russian Government that the products of their Asiatic empire will find their way to European markets by way of the Siberian rivers and the Arctic Sea, that they have already established custom-houses at the entrance to the Yenisei and the Obi.

Effects of Tobacco on the Teeth.—Habitual users of tobacco will draw some comfort from observations made by the author of a paper read before the Odontological Society of London. This writer, Mr. Hepburn, says that the direct action of nicotine on the teeth is decidedly beneficial. The alkalinity of the smoke must necessarily neutralize any acid secretion which may be present in the oral cavity, and the antiseptic property of the nicotine tends to arrest putrefactive changes in carious cavities. The author is inclined to believe that the dark deposit on the teeth of some habitual smokers is largely composed of the carbon of tobacco-smoke. This deposit takes place exactly in those portions where caries is most likely to arise, and on those surfaces of the teeth which escape the ordinary cleansing action of the brush. That tobacco is capable of allaying to some extent the pain of toothache is, he thinks, true—its effect being due not only to its narcotizing power, but also to its direct action on the exposed nerve; and he is inclined to attribute the fact of the comparatively rare occurrence of toothache among sailors in great measure to their habit of chewing.

Distribution of Luminous Power in the Sun's Rays.—With the aid of a new spectrometer based on the optical principle that a light becomes invisible when it is in presence of another light about sixty-four times more brilliant, Professor J. W. Draper has been enabled to prove that all the rays of the sun's light possess the same luminous power. In the prismatic spectrum the luminous

intensity is greatest, not in the *yellow* but in the *red;* and this effect is due to the action of the prism, which narrows and as it were condenses the colored spaces more and more as we pass toward the red, increasing the intensity of the light as it does that of the heat. But in the grating or diffraction spectrum the luminous intensity is found by Dr. Draper to be equal in all the visible regions, all the colors being simultaneously obliterated by an "extinguishing light," that is, a light about sixty-four times more brilliant. Dr. Draper describes his new spectrometer in the "American Journal of Science and Arts" for July.

The Wild Cattle of Great Britain.—In a work recently published in England is given an account of the origin, history, and present condition of the wild "white cattle" of Great Britain. The supposed primogenitors of these wild cattle were abundant in the Pleistocene age, both in the British Isles and on the neighboring continent, and in later prehistoric times they still existed, as their fossil remains testify. Advancing to historic times, the author, Rev. John Storer, quotes from Herodotus a passage in which mention is made of "large, ferocious, and fleet white bulls" abounding in the country south of Thrace. Poland, Lithuania, and Muscovy were their last strongholds on the Continent of Europe, and they became extinct there in the fifteenth or sixteenth century. But they have still living representatives in England, the Chillingham herd being the most noted. This herd is kept in the park attached to Chillingham Castle in Northumberland, the residence of Lord Tankerville. The earliest historian on this herd, Mr. Storer says, is Thomas Culley, whose book on "Live Stock," published in 1786, is pretty well known. The date of the inclosing of the park of course would probably indicate the period when the wild cattle were first confined, but there seems to be no clear evidence on this point. As long ago as the year 1692, however, there is direct proof in Mackenzie's "View of the County of Northumberland," published in 1825, that the herd then existed, for among other curious notes given therein are those of William Taylor, the steward of Chillingham: "May, 1692—Beasts in the parke. My lorde's, 16 white wilde beasts," etc. Since that period they have flourished in fluctuating numbers, never increasing very rapidly, but retaining all their wild characteristics. The herd is now generally kept up to about threescore.

Regarding the herd of wild cattle inclosed in Chartley Castle Park, Staffordshire, the property of Earl Ferrers's family, accounts alluding to them show of their existence as far back as 1658. They are more massive in character than their congeners of Chillingham, and are not so wild. From what we gather from this most interesting work, the characteristics of the two herds are such as might lead one to infer the descent of the domestic breed of shorthorns from the Chillingham herd, and the old and almost extinct "long-horn" breed from the Chartley stock. It is a remarkable fact in connection with both these herds that the animals individually are built on perfect lines, and their general *contour* is such that many of our great fat-stock breeders would be glad of such correctly formed frames to work upon.

Of the existing Scotch herds of wild cattle, the only one now found retaining to any great degree its pristine condition is the Hamilton herd in Cadgow Park, Lanarkshire. In 1874 this herd numbered some forty animals.

Other herds have existed, and some half-wild herds still are preserved in a few instances in the British Isles; of all of these Mr. Storer has given most entertaining information.

Circulating Libraries and Contagious Disease.—The question having been raised, at a meeting of the directors of the Chicago Public Library, whether books in circulating libraries may become a means of spreading contagious diseases, a committee was appointed to investigate the subject. Letters of inquiry were addressed by this committee to medical and sanitary experts, also to librarians in different parts of the country, and the replies (nineteen in number) are set forth by a member of the committee in a communication to the "Library Journal." None of the writers of the replies could give any fact falling under his own observation tending to show that a contagious disease

was ever imparted by a book from a circulating library, and hence the question had to be discussed simply as one of theory. The doctors differed, of course, some of them asserting the risk of contagion to be great, while others held it to be *nil*. The conclusion reached by the committee is that, "while there may be a possibility that contagious diseases may be transmitted by books of a circulating library, the real danger of such transmission is very small." Nevertheless, they recommend to the directors of the library "to act under the advice of the Commissioner of Health, and adopt such regulations as he had suggested, namely: that he furnish to the library, whenever he thinks proper, a list of the premises infected with contagious diseases, and of their residents; that no books be loaned to such houses until they are reported by the health office to be free from contagious diseases, and that all books returned from such houses during this period be disinfected before they are replaced on the shelves of the library."

Bird-Reasoning.—The first winter after the erection of a telegraph line on the coast of Antrim, Ireland, numbers of starlings migrating from Scotland were found dead or wounded on the roadside, they having, evidently, in their flight in the dusky morning, struck against the wires. Strange to say, during the following and succeeding winters, hardly a death occurred among the starlings on their arrival. The inference drawn from all this by a writer in "Nature" is that "the birds were deeply impressed and understood the cause of the fatal accidents among their fellow travelers, that previous year, and hence carefully avoided the telegraph wires; not only so, but the young birds must also have acquired this knowledge and perpetuated it—a knowledge which they could not have acquired by experience or even by instinct, *unless the instinct were really inherited memory* derived from the parents whose brains were first impressed by it."

Habits of the Thresher-Shark.—Having received a fine specimen of the fox, or thresher-shark, Mr. Frank Buckland sends to "Land and Water" an account of all he has been able to learn concerning the habits of that animal. Premising that what he says has to be taken with many "grains of salt," we subjoin the main points of his communication. This shark, it appears, is called "the thresher," from the power it has, in company with the sword-fish, to destroy a whale, by jumping into the air and striking the whale with its tail, the sword-fish in the mean time striking the whale from beneath. Mr. Buckland has never seen a thresher hunting mackerel, but believes that this shark "rushes into a shoal of these fish, and lays about right and left with his long tail; when the frightened mackerel are endeavoring to fall into their ranks again, the shark has a good opportunity of seizing them one by one." Of the contests between thresher-sharks and whales he gives the following animated account, on the authority of one Captain Hill, and in that worthy skipper's own words: "The thresher-sharks just do serve out the whales. The sea sometimes is all blood. A whale once got under our vessel—the Hurricane—to get away from these threshers, and when she was there we was afraid to throw a rope overboard, almost to walk about, for fear she should chuck her tail and punch a hole in our vessel. She was full length, in water as clear as gin, right under our bottom, and laid as quiet as a lamb for an hour and a half, and never moved a fin. Where they had been a-threshing of her, the sea was just like blood. I have seen these 'ere threshers fly out of the water as high as the masthead, and down upon the whale while the sword-fish was a pricking of him from underneath. There is always two of 'em—one up and one under; and I think they hunt together, and you can see the poor whale blow in great agitation; and I be bound the pair of them don't leave him till they have had their penn'orth out of him. I don't think they leaves him till they kills him."

Cost of the Proposed Lake in Algeria.—M. Roudaire, the engineer in charge of the preliminary surveys for flooding the Algerian shotts (dried up lake-beds), estimates the cost of the proposed work at not exceeding 20,000,000 francs. It is only necessary to cut through the narrow isthmus separating the head of the Gulf of Gabes

from the extremity of the shott El-Djerid, to form the proposed sea. In a letter from M. Roudaire to M. de Lesseps, the advantages which may be expected to result from the creation of this new sea are stated to be "an immense amelioration of the climate of Algeria and Tunis, since the moisture caused by the evaporation from the vast expanse of water will be driven by the prevailing southerly winds over these countries, forming a layer of humid atmosphere which will greatly mitigate the intensity of the solar rays and retard the cooling of the earth by radiation during the night. The proposed sea, too, being navigable for ships of the greatest draught, will also open a new commercial route for the districts lying to the south of the Aures and the Atlas range; while watercourses which from the south, west, and north converge toward the shotts, but which are now dry during the greater part of the year, will again become rivers, as they once undoubtedly were, leading ultimately to the fertilization of vast tracts of now desert land on their banks."

On the Antiquity of Man.—Starting from the opinion generally accepted among geologists, that man was on the earth at the close of the Glacial epoch, Professor B. F. Mudge adduces evidence to prove that the antiquity of man can not be less than 200,000 years. His argument, as given in the "Kansas City Review of Science," is about as follows: After the Glacial epoch geologists fix three distinct epochs, namely the Champlain, the Terrace, and the Delta, all supposed to be of nearly equal length. Now, we have in the Delta of the Mississippi a means of measuring the duration of the third of these epochs. For a distance of about two hundred miles of this delta are seen forest-growths of large trees, one over the other, with interspaces of sand. There are ten of these distinct forest-growths, which have begun and ended one after the other. The trees are the bald cypress (*Taxodium*) of the Southern States, and some of them were over twenty-five feet in diameter. One contained over 5,700 annual rings. In some instances these huge trees have grown over the stumps of others equally large; and such instances occur in all, or nearly all, of the ten forest-beds. This gives to each forest a period of 10,000 years. Ten such periods give 100,000 years, to say nothing of the time covered by the interval between the ending of one forest and the beginning of another—an interval which in most cases was considerable. "Such evidence," writes Professor Mudge, "would be received in any court of law as sound and satisfactory. We do not see how such proof is to be discarded when applied to the antiquity of our race. There is satisfactory evidence that man lived in the Champlain epoch. But the Terrace epoch, or the greater part of it, intervenes between the Champlain and the Delta epochs, thus adding to my 100,000 years. If only as much time is given to both those epochs as to the Delta period, 200,000 years is the total result."

The Immensity of the Stars.—We take from "Le Monde de la Science" the following interesting "Considerations on the Stars," by Professor J. Vinot: "It is known that the stars are true suns, that some of them are larger than our own sun, and that around these enormous centers of heat and light revolve planets on which life certainly exists. Our sun is distant from us 38,000,000 leagues, but these stars are distant at least 500,000 times as far—a distance that in fact is incommensurable and unimaginable for us. Viewed with the unaided eye the stars and the planets look alike, that is, appear to have the same diameter. But, viewed through the telescope, while the planets are seen to possess clearly appreciable diameters, the stars are still only mere luminous points. The most powerful of existing telescopes, that of Melbourne, which magnifies 8,000 times, gives us an image of one of our planets possessing an apparent diameter of several degrees. Jupiter, for instance, which, seen with the naked eye, appears as a star of the first magnitude, with a diameter of 45″ at the most, will in this telescope have its diameter multiplied 8,000 times, and will be seen as if it occupied in the heavens an angle of 100°. Meanwhile a star alongside of Jupiter, and which to the eye is as bright as that planet, will still be a simple dimensionless point. Nevertheless that star is thousands of times more voluminous than the planet! Divide the distance between us and a planet by 8,000,

and you have for result a distance relatively very small; but divide by 8,000 the enormous number of leagues which represents the distance of a star, and there still remain a number of leagues too great to permit of the stars being seen by us in a perceptible form. In considering Jupiter, or any of the planets, we are filled with wonder at the thought that this little luminous point might hide not only all the visible stars, but a number 5,000 fold greater—for of stars visible to our eyes there are only about 5,000. All the stars of these many constellations, as the Great Bear, Cassiopeia, Orion, Andromeda, all the stars of the zodiac, even all the stars which are visible only from the earth's southern hemisphere, might be set in one plane, side by side, with no one overlapping another, even without the slightest contact between star and star, and yet they would occupy so small a space that, were it to be multiplied 5,000 fold, that space would be entirely covered by the disk of Jupiter, albeit that disk to us seems to be an inappreciable point."

A Scientific Detective.—One of the most remarkable among recent inventions is the induction-currents balance, briefly described as follows in the "Athenæum": "It consists of two induced currents from separate induction coils, which are so equal that they neutralize each other. They are connected with three elements of a Daniell's battery, with a small clock and microphone, and a receiving telephone. If a piece of metal is placed in one of the coils, the balance of the currents is disturbed, and the clock is heard to tick; but if another piece of metal, exactly similar, is placed in the opposite coil, the balance is restored, and silence again prevails." From this brief description it will be understood that in this new instrument the physicist has an exquisitely sensitive test of the molecular constitution of many substances, for it detects the presence of mixtures and alloys, however small the quantity. Hence a scale of qualities may be formed; and if the value of silver be placed at 115° there can be no question that everything that marks 115° must be silver, 52° will be iron, 40° lead, and 10° bismuth; and, further, the instrument is at once affected by magnetism, heat, or strain in the substance under examination, and will indicate even the effect of half a minute's rubbing of a piece of metal between the thumb and finger. The induction-currents balance is a contrivance of Professor Hughes's.

Stained Windows.—The method of constructing stained-glass windows is described as follows in "Chambers's Journal": "The design of the window being determined upon, and the cartoon or full-sized drawing being prepared, a kind of skeleton drawing is made showing only the lines which indicate the shape of each separate piece of glass. It is apparently not generally understood that a window is not one piece of glass, to which are applied the various colors displayed, but a number of small pieces, which are united by grooved lead, which incloses each individual fragment, and that each different color we see is the color of that particular piece of glass, the only painting material employed being the dark-brown pigment used to define the more delicate and minute details. This skeleton or working drawing then passes to the cutting-room, where sheets of glass of every imaginable shade are arranged in racks, each bearing a number, by which a particular tint is known. The drawing being numbered on each separate piece of glass by means of a frame containing small pieces of every shade, and each numbered according to the rack containing the glass of that color, the use of this frame renders unnecessary the tedious process of visiting each rack in search of the particular shade required; the glass is laid bit by bit on the drawing, and each piece is then cut to the required shape by means of a diamond. After the glass is cut, it passes to the painter, who, laying it over the drawing, traces upon it with his brush all the details of features, folds of drapery, foliage, etc., as designed by the artist. But as the action of the weather and the continually varying conditions of the atmosphere would speedily remove every vestige of paint if left in this state, it is necessary to subject the painted glass to the action of heat by placing it for several hours in a kiln, under the influence of which the paint is fused into absolute affinity with the glass, and

becomes actually incorporated with its substance. After this burning process, it only remains for the different pieces to be united with the grooved leaden framework which binds the whole together. The places where the leads join are then carefully soldered together, and nothing remains but to thoroughly work over the whole surface with a thick kind of cement, which fills up any interstices between the glass and lead, and renders the whole panel perfectly water-tight and weather-proof."

Assimilative Power of Plants.—In a paper read before the Dublin Royal Society, Dr. C. A. Cameron states the result of a preliminary experiment made by him to determine the possibility of substituting for some of the elements in plants other elements of the same atomicity. A sod was taken from a field in which a crop of the so-called artificial grasses (which are chiefly leguminous plants, and not grasses at all) was just peeping over ground. It was placed in a box, and one half of the plants were watered twice a week with a weak solution of potassium selenate. The total quantity of potassium selenate applied to the plants during four weeks amounted to twenty grammes. The result showed that selenic acid, at least when applied in small quantity, does not injure plants. Secondly, it was found that selenic acid had been absorbed by the plants. To determine this point, the plants were partially dried and boiled in strong nitric acid until thoroughly destroyed. The solution was evaporated to dryness, and the residue was treated with dilute hydrochloric acid, which dissolved it nearly completely. The solution was concentrated and mixed with a saturated solution of sulphurous acid, whereupon the liquid assumed at once a deep, blood-red color, from the separation of selenium. The plants had been carefully washed before being dried. In concluding his paper, Dr. Cameron writes as follows: "I think this experiment proves that selenic acid is not injurious to plants when used in small quantity, and that the acid is taken up and retained by plants, or at least by certain varieties of plants. The experiment, however, did not prove whether or not there was a partial replacement of sulphur trioxide by selenium trioxide or of sulphur by selenium. Having lately become possessed of large quantities of selenium compounds, I propose to grow plants in soil or water free from sulphur in any form, but supplied with potassium and ammonia selenates. Should the results of this proposed experiment prove interesting, I shall do myself the honor of submitting them to the society."

Honey-making in the United States.—The annual production of honey in this country is estimated at about 35,000,000 pounds, and the business of bee-keeping is being rapidly systematized. One firm of wholesale grocers in New York keeps as many as 12,000 swarms; other keepers have often from 3,500 to 5,000 swarms. Arrangements are made with farmers and owners of orchards to allow an apiary of a certain number of swarms to be placed in their grounds. At the distance of three or four miles another apiary is placed with another farmer, and so on. For this accommodation the bee-keepers pay either in money or in shares. It is estimated that on an average an acre will support twenty-five swarms, yielding fifty pounds of honey each. The apiaries are cared for by men in the employ of the bee-owners. Many ingenious contrivances have been introduced for the purpose of saving the labor of the bees and the keepers. About ten years ago a German suggested that thin, corrugated sheets of wax, which he called "artificial tablets," should be provided for the bees to make their comb from. These, however, did not come into general use; but a few years ago Mr. W. M. Hoge effected an improvement by starting the side-walls of the cells. When these "foundations," as they are called, were presented to the bees, the intelligent little creatures at once took advantage of them, and extended the side-walls so as to form the regular hexagonal cell. The machine by which the impression is made on both sides of the wax is very simple, and somewhat resembles a clothes-wringing machine, only the iron rollers are studded with little hexagonal-headed pins just the size of the section of a cell, so that, when the thin sheet of wax is pressed up between the pegs to the height of about one sixteenth of an inch, it offers a substance for the construction of the cell-walls. Another remarkable adaptation of machinery is afford-

ed by the use of a rotating frame, which causes the cells of the comb placed in it to be emptied by centrifugal force. The empty, uninjured comb is afterward replaced in the hive, and again used by the bees. As about three fourths of the time of the bees, it has been computed, is taken up in the construction of the comb, it will be seen that by these contrivances a great saving of bee-labor is effected.

Brain-Texture and Mental Make-up.—The members of the Paris Anthropological Society were not a little surprised by the tenor of a report made by M. Thulié upon the appearance of the brain and cranium of M. Asseline, one of their fellows, lately deceased, at the age of forty-nine. M. Asseline belonged to a "society for mutual autopsy," and the examination of his brain was made by his bereaved *cosocietaires*, who were prepared to find in it all the commonly received external indications of a highly refined and intellectual nature. He had been a republican and a materialist; possessed enormous capacity for work, great faculty of mental assimilation, and an extraordinarily retentive memory; had a gentle, kindly disposition, keen susceptibilities, refined taste, and subtile wit. As a writer he had always displayed great learning, unusual force of style, and elegance of diction; and in his intercourse with others he had been unassuming, sensitive, and even timid. But "the autopsy showed," says "Nature," "such coarseness and thickness of the convolutions that M. Broca presumed them to be characteristic of an inferior brain. The fossæ or depressions regarded by Gratiolet as of a simian character, and as a sign of cerebral inferiority, which are often found in women, and in some men of undoubted intellectual inferiority, were very much marked, especially on the left parieto-occipital. But the cranial bones were at some points so thin as to be translucent; the cerebral depressions were deeply marked, the frontal suture was not wholly ossified, a decided degree of asymmetry was manifested in the greater prominence of the right frontal, while, moreover, the brain weighed 1,468 grammes—i. e., about sixty grains above the average given by M. Broca for M. Asseline's age."

NOTES.

THE important statement is made by Professor C. V. Riley that for the feeding of silkworms there is no appreciable difference between the leaves of the osage orange and the mulberry, provided care is taken to reject the more tender and milky leaves of the former, as they are apt to produce flaccidity and disease.

A WRITER in "Nature" suggests the employment of carrier-pigeons in the British meteorological service as a means of bringing accounts of the weather at different points in the Atlantic Ocean 300, 400, or even 500 miles out, the pigeons being dispatched on outward voyages of ships leaving such ports as Queenstown, Southampton, etc. The present great difficulty of the meteorological service of Europe is that storms reach the coast unannounced over the Atlantic.

UPON the publication of Siemens's remarks on conveying to a distance, by means of electricity, the power developed by the Falls of Niagara, several electricians declared the idea to be preposterous. Thus one writer calculated that the thickness of the cable required to convey to the distance of several hundred miles the current which could be produced by the power of Niagara, would require more copper than exists in the whole of the Lake Superior region. Another statement estimates the cost of the cable at about sixty dollars per lineal foot. But calculations made by Professor Elihu Thomson and Edwin J. Houston, of Philadelphia, show that these estimates are erroneous, and that it is possible to convey the total power of Niagara a distance of five hundred miles or more by a copper wire not exceeding one half inch in thickness. Even though in practice this result be unattainable, the important fact still remains that, with a cable of very limited size, an enormous quantity of power may be transferred to considerable distances.

BERNHARD VON COTTA, the eminent Saxon geologist and Professor of Geology in the University of Freiberg, died at that place September 14th, at the age of seventy-one years. He was an indefatigable student and writer, and his published works are very numerous. His first book, on "The Dendroliths," was written while he was yet a student at Freiberg. Later he was associated with Naumann in preparing the geological map of Saxony. The first volume of his "Geognostic Travels" appeared in 1836, and the second in 1838. One of his principal works, namely the "Introduction to the Study of Geognosy and Geology," first published in 1839, passed through sev-

eral editions. But his greatest work was undoubtedly his "Geologie der Gegenwart" (The Present State of Geology). This work has passed through five editions. A few of his works have been translated into English and other languages of Europe.

THE metal *scandium*, obtained by its discoverer Nilsson from ytterbine, has lately been found by P. Clève in yttrotitanite from Norway. The only oxide of scandium, *scandine*, appears to possess the formula Sc_2O_3. The atomic weight of the new metal is 45. Scandine is a pure white powder, light, infusible, and resembling magnesia. The hydrate of scandium is a white and bulky precipitate like hydrate of alumina. The scandium salts are colorless or white; they have an astringent and very sour taste, very different from the sugary taste of the other yttria earths. Scandium is one of the metals predicted by Mendelejef; he gave it the name of *ekabor*, and fixed its atomic weight at 44. The characters of ekabor correspond pretty closely with those of scandium.

BY means of his new spectroscope, with compound sulphide of carbon prisms, M. Thollon has produced a remarkable map of the solar spectrum. This map is no less than ten metres in length, and is composed of about 4,000 lines. M. Thollon has devoted great care to reproducing the physiognomy of each line; and there are many new features revealed which will doubtless be utilized for theory.

THE German Empress, Augusta, soon after the death of the young Prince Waldemar, son of the German Crown-Prince, offered a considerable sum of money as a prize for the best essay on "Diphtheria, its Nature and Treatment." A commission of eminent physicians has been appointed, with Dr. von Langenbeck, of Berlin, as chairman, to award the prize. The lists will remain open until December 15, 1880. The competing essays may be written either in German, French, or English.

DURING the first six months of the present year, regular tides have been observed in the subterranean waters of the Fortschritt mine in Bohemia. This strange phenomenon has attracted the attention of the Academies of Science of Berlin and Vienna, but as yet no adequate explanation of it has been proposed.

A CHINAMAN was fined ten pounds for "sweeping the streets" in an Australian town. In explanation, it may be mentioned that the streets are metaled with quartz, which is crushed to powder by vehicles, and that the sweepings often give a very lucrative return in gold-washing. Here the gold return is largest when the streets are left unswept!

THE Rev. Dr. Barnard, President of Columbia College, New York City, in his last annual report, warmly advocates the co-education of young men and young women in colleges. It is, he says, mainly the spirit of conservatism which opposes the opening of colleges to women, rather than anything inherently objectionable in the proposition itself. That this is so, is made evident by the fact that no such opposition manifests itself to the association of students of both sexes in academies and high-schools, many of which profess to teach the same subjects as the colleges, to the same extent, and to pupils of similar ages.

THE historian of civilization in some distant future period will probably quote the following passage from a letter written by a British officer in Zululand, as an illustration of the state of civilization existing in the last quarter of the nineteenth century. This officer writes: "I flatter myself that I put an end to six promising young Zulus. We expected no quarter and gave none. When the fighting was over, some of our native troops were sent out on the errand of dispatching the wounded, many of whom had crawled away into the long grass, and even into the ant-bear holes, but our allies were even with them all round."

AT Baku, on the Caspian Sea, the residue (*astalki*) left after the final distillation of petroleum is produced in such enormous quantity that its price is only nominal, and much of it is poured into the sea for lack of stowing space or demand. For years it has been the only fuel used on board the war-ships and mercantile steamers of the Caspian. It is employed in cooking also, and for the production of illuminating gas. In the latter case it is allowed to trickle slowly into retorts raised to a dull-red heat, pure gas with a little graphite being the result. Weight for weight, astalki gives four times as great a volume of gas as ordinary coal.

ACCORDING to Gerard von Schmitt, physician and traveler, the plant *Mikania guaco* possesses medicinal properties very efficacious in the treatment of cancer and allied diseases.

THE following is Hersch's test for sewage contamination, or the presence of putrescible organic matter in water: Fill a clean pint bottle three quarters full with the water to be tested, and in it dissolve half a teaspoonful of the finest sugar; then cork the bottle and set it in a warm place for forty-eight hours. If, meanwhile, the water becomes cloudy or milky, it is unfit for domestic use. If it remains perfectly limpid, it is probably safe to use.

HEINRICH WILHELM DOVE.